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RECORDS
OF
THE GEOLOGICAL SURVEY OF INDIA

Part 4] 1924 [June

HENRY HUBERT HAYDEN: BORN JULY 25TH 1869. DIED AUGUST 1923.

IT is with the greatest regret that I have to record the death of Sir Henry Hubert Hayden, C.S.I., C.I.E., B.A., B.A.I (Dub.), D. Sc. (Calcutta), F.R.S., F.G.S., F.A.S.B., formerly and recently Director of the Geological Survey of India. Educated in Natal and in Dublin University he joined the Geological Survey of India on the 21st February 1895. In addition to his usual duties he was appointed Curator of the Geological Museum and Laboratory on the 1st January 1897, and from the 27th November 1902 till the 23rd February 1903 he acted as Superintendent of the Indian Museum; on the 25th February 1903, he was promoted to Deputy Superintendent, and on the 2nd May 1904 to Superintendent, on the 1st December 1910 he was appointed Director, and after being accorded the official honours of C.I.E. in 1911 and C.S.I. in 1919, received the honour of Knighthood on his retirement from service on the 1st June 1921, for his valuable services to this country.

Sir Henry Hayden was a great traveller and his name will, for all time, be associated with the geology of the Himalaya and of Tibet. He spent his first camp season in Burma investigating the occurrences of statuary marble, rubies, sapphires and spinels of the Mandalay district and Sagyin Hills, examining the coal outcrops of Mithwe in Bhamo, exploring the extinct volcano of Mount Popa, and making a traverse across the unhealthy Arakan Yoma to the steatite quarries of Hpa-aing. In 1897-98 he was attached to the Tirah Expeditionary Force and afterwards published a short Memoir on the result of his work. Subsequent activities included an exhaustive and illuminating survey of Spiti and Lahaul where he discovered the now classic section of Cambrian rocks; an examination of the mica mines of North Hazaribagh; a survey with Dr. Hatch of the gold deposits of Wynaad; an examination of the railway hill section around Haflong in Assam; a journey to the Palni Hills; a survey of various glaciers in Kashmir; a survey of the oil and coal fields of Upper Assam and the Naga Hills. In 1903-04 he made his first acquaintance with Tibet by accompanying the Tibet Frontier Commission. This country seems to have put a spell upon him which he never lost. He made a study of its language which he maintained for years in Calcutta with the help of a Tibetan *munshi*, in the hope of returning to the land which had so fascinated him. His liking for Tibet and its people seems to have been reciprocated, for I doubt if any other traveller can boast of having won the confidence of these suspicious folk to the same extent as did Hayden. His treatment of coolies and local officials was governed by a most efficient mixture of tactful kindness and manly firmness. It was always a matter of great satisfaction to him that he had left things easy for any traveller coming after him. This idea seems to have taken a very strong hold on him, and to follow in his foot steps, as the present writer has often done, invariably meant a ready welcome, generous hospitality and loyal assistance.

During 1907-08 his services were lent to the Amir of Afghanistan, and our knowledge of the geology of that country is practically restricted to his memoir and map on the subject and to some papers by Griesbach. In 1913-14 he crossed Chitral into the Pamirs and Central Asia, and made his way into Russia by the Siberian Railway to find that the war had broken out. He reached England *viâ* Scandinavia and at once offered himself for military service. It was one of the greatest disappointments of his life that he was not allowed to join up. On his return to India he flung himself with unsparing and characteristic energy into the development of the wolfram, mica and other mining industries on which the Allies depended.

On retiring from the Geological Survey of India another disappointment met him, for the Government of India refused, on account of his age, to allow him to represent the Geological Survey on the first Mt. Everest Expedition. In 1921 he made a private expedition into Tibet accompanied by an Italian guide, M. Cosson, and returned to Calcutta in the Cold Weather of 1922-23. From a scientific point of view the results of his investigations proved a little disappointing owing to the disturbed conditions of the rocks. It is hoped to publish shortly the results of these researches which will undoubtedly form a most valuable addition to our scanty knowledge of the Central Asian plateau.

He was the author of some 40 papers and memoirs in the "Records and Memoirs of the Geological Survey of India", and of numerous other contributions in scientific Journals. His best known works are "The Himalaya Mountains and Tibet" in which he collaborated with Sir Sydney Burrard, "The Geology of Tirah and the Bazar Valley" already mentioned "The Geology of Spiti, with parts of Bashahr and Rupshu," "The Geology of the Provinces of Tsang and Ü in Central Tibet," "Some Coal fields in North-Eastern Assam," "The Geology of Northern Afghanistan," "Notes on the Geology of Chitral, Gilgit and the Pamirs," and several reviews of the Mineral Production of India. Outside his official duties he took a keen interest in many forms of education and literary activity. He was a past president of the Asiatic Society of Bengal and also of the Mining and Geological Institute of India, and was largely instrumental in setting the Indian Science Congress upon its feet. He was elected a Fellow of the Royal Society in 1915, and was awarded the Bigsby medal by the Geological Society of London the same year. During his Directorship the cadre of the Geological Survey of India was greatly increased.

His death was due to a climbing accident on his return with his two guides from an ascent of the Finsteraarhorn in the Berner Oberland soon after August the 12th, 1923; his body and those of his guides were not found till August the 28th. The accident occurred on the rock arête below the Hugi sattel. Possibly the top of the ridge which is of loose rock may have given way bodily, but the fact that the heels of Cosson's boots were found afterwards to have been torn off points to a gallant but unavailing effort on his part to stop the fall. It is characteristic of Hayden that he insured the life of this guide, who was married, before their expedition together to Tibet.

A man of the most generous impulses, with a contempt for all forms of pettiness and intrigue, he had the peculiarly attractive gift of making friendship with him a bond between his friends. His sense of honour was almost meticulous. In his horror of affectation and pharisaism he frequently endeavoured to conceal one of the kindliest hearts that ever beat beneath an apparent brutality which, however, was so overdone as to deceive none. His attitude towards Science was of that peculiarly English type of simple, childlike self-effacement, combined with a sturdy championship of what he felt was the truth. His characteristic was more that of a healthy perspective than of intensive and brilliant insight, and the solid results he obtained are responsible for a notable and invaluable advance in our knowledge of Himalayan and trans-frontier geology.

Science has lost a devoted and selfless follower whom she can ill spare, and his friends mourn the loss of an attractive and sympathetic personality, a loyal friend and a generous and gallant soul.

THE OIL-SHALES OF EASTERN AMHERST, BURMA, WITH A SKETCH OF THE GEOLOGY OF THE NEIGHBOURHOOD.

BY G. DE P. COTTER, SC.D. (DUB.), F.G.S., *Superintendent, Geological Survey of India.* (With Plates 34 and 35.)

PART I—GEOLOGY.

Introduction.

IN November and December 1921, I examined the east of the Amherst district, especially such areas as showed exposures of oil-shales. These oil-shales are the only ones hitherto known in the Indian Empire, and are of Tertiary—probably late Tertiary—age. They occur in synclinal cuvettes or basins resting unconformably upon older rocks. The facies is fresh-water, the shales containing numerous fish remains and dicotyledonous leaves. These basins may be compared with similar Tertiary basins in the Shan States and in Tavoy, which have been mapped by T. D. LaTouche,[1] and Drs. J. Coggin Brown and A. M. Heron[2] respectively, or by members of their parties. But those other basins contain coal-measures or rather lignites, and do not, so far as is known, carry oil-shales.[3] The existence of oil-shales in the Amherst district has been known for several years, but hitherto no account of them has been published. The district itself is one which has been neglected as far as the making of either topographical or geological maps go. Besides a small-scale map (1 inch=8 miles) the only maps of eastern Amherst are Forest maps. These are indeed useful, and are on a sufficiently large scale (4 inches=1 mile) to satisfy the most exacting, but unfortunately they map only Forest Reserves, while cultivated areas remain blank. The map accompanying this paper is reduced from

[1] LaTouche : "Geology of the Northern Shan States." *Mem., Geol. Surv. Ind.*, Vol. XXXIX, (1916).

[2] Brown and Heron : "Geology and Ore Deposits of Tavoy." *Mem., Geol. Surv. Ind.*, Vol. XLIV, pt. 2, (1923).

[3] But Rao Bahadur M. Vinayak Rao has since discovered oil-shale in Mergui district. See *Rec., Geol. Surv. Ind.*, Vol. LIV, pp. 342-343, (1923).

the Forest maps, and contains such additional details as I have been able to add by means of pocket compass and pacing. Towards the close of my tour in Amherst, I was joined by Capt. F W. Walker, who made some valuable additions to our collections of fossil leaves and fishes from the vicinity of Htichara.

The part of the Amherst district herein described lies east of the Dawnas—a range of mountains which, according to the Amherst district gazetteer, rises to a height of 5,500 feet, in latitude 16°5′ North. To the north it extends in a north-north-west alignment, while at the same time decreasing somewhat in altitude. About latitude 17°15′ it is joined by a range of hills known as the Choehko Taung, which spreads to the north into a hilly plateau with rugged limestone peaks. The highest point of this group of hills is the Delaw Taung (2,919 ft. high lat. 17°2′, long. 98°20′). Another, better known peak is the Kamawkala Taung (height 2,239 ft., lat. 17°2′, long. 98°25′).

The Choehko Taung, which runs generally north-east to join the Dawna range, encloses between itself and the Dawna a broad open valley drained by the Mepale river, and it is in this valley, which is a structural one, related to the system of folding of the rocks, that the main Tertiary basin in which oil-shale is found occurs.

This basin lies entirely in British territory while the remaining basins described in this paper lie partly in Burma and partly in Siam. The Mepale river joins the Thaungyin river about 4 miles north-west of the town of Myawaddy; at the junction, rocks of pre-Tertiary (probably Jurassic) age are exposed.

The Thaungyin river, a large stream navigable by rafts from Kyaukket south of Myawaddy to Mitan, but with a few rapids near the Kamawkala gorge, and numerous rapids below Mitan, forms the boundary between Siam and Burma, until it reaches its confluence with the Salween river. Thus the Thaungyin forms the eastern boundary both of Amherst and of Thaton districts. This river shows in various places exposures of oil-shale, and it is clear that there is a basin of Tertiary rocks between Kyaukket and Myawaddy, and again Tertiary rocks north of Myawaddy between this town and the Kamawkala gorge. But it is uncertain whether or not these two basins unite with one another in Siam. No attempt was made to examine any part of Siam, except the actual shores of the Thaungyin river itself.

We may however recognise two basins bisected by the Thaungyin; of these that south of Myawaddy may be referred to as the Phalu basin while that to the north of Myawaddy may be known as the Mesauk-Methalaun-Melamat basin. The third basin, mentioned above as lying entirely in British territory, and in the valley of the Mepale river is that of Htichara, and derives its name from the village of Htichara, near which the main boring operations have been carried out by Messrs. M. E. Moola & Sons, Ltd.

Geological Formations.

According to my interpretation of the geology, the oldest rocks exposed in the east of Amherst district are the banded gneisses and schists and gneissose granites of the Dawna range. The alternative to my view is to suppose these gneisses and granites to be contemporaneous with the granite of Tavoy and Mergui, but the great lithological dissimilarity and the metamorphosed condition of the Dawna gneiss is against such a correlation. The Mergui series, a formation extensively developed in Tavoy and Mergui, is possibly represented by a small outcrop of hornblendic quartz schist seen on the bank of the Mepale, 2½ miles S.W. of Tawokywa. The hills between the Dawna range and the Siamese frontier are composed mainly of two formations, a limestone group, and a red sandstone group which overlies it unconformably. The limestone forms the cores of the main hill ranges, producing rugged and castellated profiles; similar profiles in the distant Siamese ranges across the Thaungyin river show that limestone composes the centre of these ranges also. I have named this limestone the Kamawkala Limestone from the Kamawkala peak (see above) which is one of the best known peaks of this formation. The Kamawkala limestone is doubtfully regarded by me as of Triassic age. Above this limestone, the Red Sandstones rest unconformably. Their great similarity to the Red Sandstones of Kalaw inclines me to the view that, like these they are of Jurassic age. Both the Kamawkala Limestone and the Red Sandstones are highly disturbed, often vertical. With the Red Sandstones is associated a conglomerate, which may possibly be of later age than the main bulk of the Red Sandstones. Above all these formations rests unconformably the Tertiary group, the upper division of which contains oil-shale. The Tertiaries are divisible broadly into two groups:- A, a lower group of sands, boulder beds, and conglomerates, and B, an upper group mainly of shales, and in which oil-shales are developed.

The formations may now be tabulated as follows:—

(1) Dawna Gneisses and Schists	Possibly Archæan.
(Junction with following not seen.)	
(2) Hornblende Quartz Schists near Tawokywa	Probably Mergui series (Pre-Cambrian).
(Junction with following not seen.)	
(3) Kamawkala Limestone	Lower Mesozoic probably Triassic.
(Unconformity.)	
(4) Red Sandstones	Equivalent to the Kalaw Red Sandstones, probably Jurassic.
(with which is associated)	
(4A) Conglomerates of limestone and red sandstone pebbles	Also found at Kalaw; may be part of Red Sandstone series or later.
(5) Tertiary Beds	
Division A. Sands, conglomerates and Boulder Beds	Probably newer Tertiary.
Division B. Shales with oil-shales interbedded	Ditto.

Dawna gneissose Granites.

In considering the age of the granites and schists of the Dawna Mountains, attention must be paid to the geology of neighbouring countries, such as Siam, Tavoy, and the Shan States. In each of these areas granites and gneisses occur, the age of which has not yet been absolutely settled. In the Shan States Archæan gneisses of an acid type occur near the Katha district, and extend into northern Burma. Biotite-gneisses and biotite granulites are common into which veins of pegmatite, graphic granite and aplite are intruded.[1] They are known as the Mogok Gneiss.

The age of these rocks is unquestionably Archæan. Later granites are found intrusive into the mica schists of Mong Long,[2] these mica schists are regarded by LaTouche as Purana (Algonkian) in age.

The age of these latter intrusive granites is not evident, but it is probable that they may be post-Palæozoic. In 1912 Mr. P. N. Datta[3] found in the Kyaukse district granite intrusive into older rocks, these last being shale, sandstone, and limestone, all rather metamorphosed. Mr. Datta regarded the limestone as Palæozoic, in which case it is probably to be correlated with the Plateau Limestone of LaTouche, which ranges from Devonian to Permian. In LaTouche's map the hills in the north of the Kyaukse district

[1] *Mem., Geol. Surv. Ind.*, Vol. XXXIX, p. 34.
[2] *Ibid*, p. 47.
[3] *Rec., Geol. Surv. Ind.*, Vol. XLIII, p. 29.

are shown as Plateau Limestone, while recent work near Kalaw has shown the presence of Plateau Limestone east of Kalaw. Thus the limestones to the immediate north and to the south-east of Kyaukse are Plateau Limestones. It would appear therefore quite probable that the limestone seen by Mr. Datta in the Kyaukse district is also part of the Plateau Limestone series, and that the granite is therefore post-Palæozoic. If this is the case, perhaps we may regard the intrusive granite of Mong Long as of like age.

We therefore seem to have evidence of two different granites in the Shan States and North Burma, *viz* (1) Archæan granites and gneisses of Mogok, and (2) Intrusive granites of post-Palæozoic age. Turning now to Tavoy, we find that the later intrusive granite is the only granite recognised. It contains, according to Drs. Brown and Heron,[1] veins of tourmaline pegmatite, and itself frequently possesses a pseudo-foliation which, although resembling gneissic structure, is not truly so. It is here intrusive into the Mergui series, which Drs. Brown and Heron regard as Pre-Cambrian.

In the present year (1922) Mr. E. L. G. Clegg examined the head waters of the Yunzalin river in the Salween district. The geological information obtained in this tour gives us some data wherewith to link up the geology of the Shan States with that of Amherst. Mr. Clegg recognises the following formations in descending order :—

(1) Plateau Limestone.
(2) Granite, intruded into (3).
(3) Chaung Magyi Series.
(4) Gneisses with intruded granites and quartz.

Here again two different granitoid series are recognisable, and we may perhaps correlate the earlier granites and gneiss with those of Mogok on the one hand and of the Dawna on the other, while the later granite is perhaps equivalent to the Mong Long granite of the Northern Shan States and to the granite of Tavoy. The Dawna gneiss is a rock quite different to the Tavoy granite. I have shown specimens to Drs. Brown and Heron, who agree with this view. Nowhere in Tavoy is the banded gneiss typical of the Dawna found.

The geology of Siam is known from a description by Mr. Bertil Hogböm,[2] whose valuable paper sheds much light upon the geo-

[1] *Mem., Geol. Surv. Ind.*, Vol. XLIV, p. 191.

[2] "Contributions to the Geology and Morphology of Siam." *Bull. Geol. Inst. of Univ, of Upsala*, Vol. XII, pp. 65-127.

logy of the Siam-Burma border, and must be taken into account in any description of the geology of Amherst district. Mr. Hogböm (p. 111) considers that "the igneous rocks are of different epochs, as is shown by the fact that there occur quite schistose rocks together with such as do not show any perceptible traces of pressure. Most of them are found in the Pre-Carbonian[1] series, often metamorphosed beyond recognition, but others are met with penetrating the Triassic strata; finally the Tertiary or recent basalts may be mentioned. The granitic rocks ought generally to be considered as relatively young and at least partly penetrating Triassic strata; I have but seldom found gneissic granitic rocks." Near Rahang on the Mei Ping river, about 40 miles east by north of Myawaddy, Mr. Hogböm found granite associated with a limestone which is undoubtedly to be correlated either with the Kamawkala or the Moulmein Limestones. He states that sometimes this granite has the appearance of an eyed gneiss. He adds "The granite in question, as I have mentioned, is obviously entangled in the tectonic movements, but it may be considered as younger than the limestone beds. No evidently intruded veins of it could, however, be observed in the limestones unless possibly further down the river, where it outcrops alternatively with vertically upraised limestone beds. If this is the effect of strong folding or intrusion could, however, not be determined, as no immediate contacts could be found and examined, here or anywhere else along the river. It may be mentioned that granitic rock is not very resistant in the tropics, and thus it is not much exposed.'

The weight of evidence is then in favour of recognising two very different granitoid systems, *viz.*

(1) Granitoid gneiss with pegmatites of Archæan age, represented by the Mogok Gneiss of Katha, and the Dawna Gneiss of Amherst;

(2) Post-Palæozoic granites represented by the granite intrusions of Kyaukse district and by the granites of Tavoy and Mergui.

Description of Dawna Granites.

The Dawna Mountains are crossed by the cart-road from Kyundo and Kawkareik to Myawaddy. This cart-road has staging bungalows at convenient intervals. Leaving Kyundo on the Haung-

[1] By the expression "Pre-Carbonian" Mr. Hogböm means *Pre-Carboniferous.*

thraw River, a motor road runs fifteen miles to Kawkareik, the sub-divisional headquarters of the Kawkareik sub-division. The way lies over alluvium, but some whitish clays and grits are visible between milestones 10 and 12, the age of which is not known. Possibly they are Mergui series. Kawkareik is itself on alluvium mainly, but the Forest Bungalow is built on a hill showing exposures of light grey shales and indurated mudstone.

The next stage beyond Kawkareik leads to a bungalow known as Third Camp, which is 23½ miles distant from Kyundo. Near the 20th milestone are exposures of blue shale and mudstone of unknown age—possibly Merguis—but the main deposit is alluvium until the neighbourhood of Third Camp is reached. The first exposure of igneous rock is at the 22nd mile and 5th furlong. Here coarse tourmaline granite pegmatite is seen intrusive into biotite schist.

The granite pegmatite is a pure white rock composed mainly of felspar and quartz with sparse crystals of tourmaline. Flakes of muscovite occur, but are rare, while biotite was not seen. The felspar is seen under the microscope to consist of orthoclase, abundant microcline and in lesser quantity plagioclase having the extinction angles of albite or oligoclase. Quartz is also abundant, both quartz and felspar being allotriomorphic and in fairly large crystals. The biotite schist shows abundant biotite, sometimes bleached, and some muscovite (sericite) probably of secondary origin. Quartz in small grains is fairly common, and grains of plagioclase felspar are less abundant. The intrusive tourmaline granite pegmatite is frequently exposed on the road leading from Third Camp to Thingannyinaung, which last village is not quite 46 miles from Kyundo, and is on the main road to Myawaddy. But the type most characteristic of this section is a schistose biotite-gneiss, usually well banded, made up of crystals of quartz felspar (orthoclase and microcline) and biotite. A specimen from an exposure at the 26th mile and 1st furlong shows a fibrous mineral, probably fibrolite, abundantly present in a rock which may be described as a fibrolite-biotite-quartz gneiss.

Crystals of beryl are said to occur in the pegmatite, but none were seen by me. Sapphires and rubies are reported to occur near Myawaddy[1] but no corundiferous pegmatites were found in the sections through the Dawna gneiss which I visited.

[1] Amherst District Gazetteer, Vol. A (1913), p. 42.

The Mergui Series.

About 2⅜ miles south-west of Tawok on the west bank of the Mepale river a well bedded, greenish-grey, hornblendic quartz schist is seen. The dip is steep and to the N. E. No rock of a similar type was seen in any other part of the country visited. It resembles some of the rocks of the Mergui series, and has been provisionally placed in this group.

The Kamawkala Lime-stones.

The Kamawkala Limestones are exposed near the Htichara Forest bungalow about 3 miles north of Htichara, and extend northwards from this point, so as in all probability to join up with the limestones exposed in the Kamawkala gorge of the Thaungyin river, which lies about 15 miles to the north. The limestone is unconformably overlain by the Red Sandstone series, from beneath which it outcrops, both in this main exposure which runs north from Htichara to Kamawkala, and also in several minor inliers in the hills north-east of Htichara and in the Thaungyin river. Similar limestones are found south and west of Phalu, and in the hills south of Thingannyinaung, but they have not been mapped. The hill-ranges in Siam east of the Thaungyin are castellated and obviously limestone, perhaps part of the same series.

The limestone is of a grey colour, hard and crystalline, frequently showing a network of veins of calcite; under the microscope it sometimes shows anoolitic structure of a miniature type. A careful search in the neighbourhood of Htichara Forest Bungalow failed to disclose any trace of fossils, and the weathered surfaces of the limestone showed no trace of any organic structure. This is due partly to the fact that there are no waterworn smooth surfaces in the small streams, but rather a coating of travertine, and a covering of moss and lichen.

But towards the close of my tour I examined the sections exposed in the Thaungyin from Phalu to Kamawkala. On this traverse I encountered several outcrops of limestone with smooth water worn surfaces. In these exposures occasional traces of fossils were discovered from the following localities :—

(1) An exposure of grey limestone on the southern bank of the Thaungyin river, east of Htichara, and S.S.W. of the hill marked Lewa Taung on the Forest map, *latitude* 16° 47′ 15″, longitude 98° 32′ 3″. Here were found corals both simple and compound, a *Lima*-like shell and fragments of brachiopods.

(2) In the Thaungyin on both sides of the river in a small gorge with limestone on both banks, situated about two miles east of the Kamawkala gorge in latitude 17° 3′ 18″, longitude 98° 26′ 55″.

Here sections of ammonites were found and some rhynconellids.

(3) In the Kamawkala gorge of the Thaungyin in latitude 17° 3′ 20″ and longitude 98° 25′ 15″.

This locality also yielded ammonites and rhynconellids.

The collections from these three localities were sent from Burma to Mr. G. H. Tipper, then Palæontologist to the Geological Survey, for examination, it not being possible, owing to the absence of palæontological literature in Rangoon, to work them out myself. He remarks that the limestones in which the fossils occur are so crystalline that it is impossible to develop the fossils further or to obtain information from their sections. The state of preservation of the ammonites which occur in localities (2) and (3) is poor, but probably all belong to one genus,—an involute form with rather fine continuous ribs. Badly worn sutures are seen on two specimens. Associated with the ammonites are many small acuminate *Rhynchonellae* with well developed ribs and a well marked sinus. From locality (1) there was obtained a badly weathered section of a gastropod with a long spine, unfortunately unidentifiable. There were two ribbed *Pecten*-like lamellibranchs, but the state of preservation was so poor that it was uncertain whether they belonged to *Pecten* or to *Lima*.

Colonial and solitary corals also occur, the former being apparently close to *Latimæandraria* while the latter has not been identified. Mr. Tipper concludes by expressing the opinion that, on the assumption that these fossils come from one horizon as seems likely, it can only be said that they are probably Lower Mesozoic in age, a closer approximation being impossible without better preserved material.

The attribution of a Lower Mesozoic age to these limestones is rather surprising in view of the fact that the limestones of the Shan States, have been proved to be Devonian to Permian,[1] those of Mergui to be Carboniferous,[2] those of the hills north of Moulmein

[1] LaTouche, *op. cit.*
[2] Noetling : *Rec., Geol. Surv. Ind.*, Vol. XXVI, p. 96.

to be also Permo-carboniferous,[1] and the limestones of Siam to be also Permo-carboniferous.[2]

If therefore Mr. Tipper's conjecture is correct it would appear that the Kamawkala limestone is later than the great bulk of the limestones of neighbouring areas. The state of preservation of the fossils is disappointingly poor, and there must remain an element of doubt in the attribution of a Triassic age to these limestones. If however these limestones are really Triassic, it is perhaps possible that they are an upward extension of the Plateau Limestone into the Trias.

The limestone is usually vertical or steeply dipping, generally with a strike to N.N.W., that is parallel with the mountain chains of the area. It is frequently contorted and crushed, although in a less degree than that of the Shan States.

The Red Sandstone Series.

That the Red Sandstone series of East Amherst is as widely spread a formation as the limestone upon which it unconformably rests is evident from the following considerations:—

Purple and red sandstones were observed by Mr. C. S. Middlemiss in the neighbourhood of Kalaw in the Southern Shan States; these beds were associated with sandstones and shales with coal. The lithological appearance of the Kalaw red sandstones is very similar to that of the Amherst red sandstones. Especially a conglomerate made up of pebbles both of red sandstone and of limestone in a matrix of red calcareous fine grained sandstone is found in both areas. The age of the Kalaw red sandstones was vaguely determined by the discovery by myself in January 1922 of fossil plants in the roof of the coal seams near Kalaw. My collection of fossil plants was largely augmented by my colleague Capt. F. W. Walker. I identified the following specimens :—

Cladophlebis denticulata Brong.
Gingkoites digitata Brong.
Pagiophyllum divaricatum (Bunb.).
Brachyphyllum expansum (Sternb.).
Ptilophyllum sp. cf. *P.* non *Otozamites hislopi* (Oldh.).
Podozamites distans (Morris).

[1] Theobald: *Mem., Geol. Surv. Ind.*, Vol. X, p. 326; T. Oldham: "Coal and Tin of Tenasserim." *Rec. of Govt. of India* No. X, page 33; *Rec., Geol. Surv. Ind.*, Vol. LIV, p. 54.
[2] Bertil Hogbom, *op. cit*

These indicate a Jurassic age, but there are no characteristic Rhaetic or later species, and they might conceivably belong to any part of the Rhaetic or Jurassic.[1]

The Namyau series of the Northern Shan States, described by LaTouche is characterised by its red and purple coloured sandstones and contains a brachiopod fauna of Bathonian age.[2]

Reddish and purple sandstones of unknown age rest unconformably upon Mergui rocks in the islands of Mergui town[3]; it seems not impossible that these are of like age. Red sandstones with conglomerates and shales extend through Siam into Tonkin. At Luang Prabang and in Tonkin Rhaetic fossils have been found, but from some of the lignite beds plants of probable Liassic age have been found.[4]

The Red Sandstones of Amherst, which will be afterwards described in detail, have yielded fragmentary fossils all unhappily unidentifiable and mainly lamellibranchs. Amongst these an *Astarte* not unlike some of the Jurassic species, seems to be most common.

Enough has been said to show the probability that these Red Sandstones are to be correlated broadly with those of the Northern Shan States, Kalaw, and of Siam and Tonkin. May we add also with those of Mergui? There is no fossil evidence for this last correlation which although very possible is at present quite unproved.

Description of the Red Sandstone Series.

As may be seen from the map accompanying this paper, the Tertiary basin of Htichara rests on the west upon Dawna gneiss, and upon the north, south, and east upon either Kamawkala Limestone or upon the Red Sandstone series. This series together with the Kamawkala Limestone occupies all the hilly country east of Htichara. The Red Sandstone hills are easily distinguished at a distance from those of limestone by their rounded contours contrasting with the rugged pinnacles and castellated profiles of the limestone hills. Besides the large mass of limestone north of Htichara Forest Bungalow, which probably extends to Kamawkala, there are several small crags of limestone protruding from the overlying Red Sandstones. Two such crags can be seen about three miles

[1] C. S. Middlemiss in *General Report of the Geological Survey of India for 1899-1900*, p. 143.

[2] *Op. cit.*, p. 303.

[3] *Rec., Geol. Surv. Ind.*, Vol. LIII, p. 26, and Vol. LIV, p. 50.

[4] B. Hogbom, *op. cit.*, pp. 107-108, and Zeiller: "Flore fossile des couches de charbon du Tongking."

N.E. of Htichara, while others occur near the Thaungyin river east of Htichara in latitude 16°47′. The manner in which these curious pinnacles of limestone protrude from beneath the Red Sandstone gives me the impression that the craggy profiles and steep conical hillocks of the former are due in large measure to a pre-Jurassic denudation, which, after having been concealed during the Cretaceous and Tertiary periods by covering deposits of Jurassic Red Sandstone, is again becoming partially revealed in recent times by the continued denudation of this sandstone. This hypothesis may account for some rather puzzling occurrences. In longitude 98° 28′ 3″ and latitude 17° 1′ 30″ north of the junction of the Lehpo chaung with the Thaungyin, the Red Sandstone appears in one section to overlie and in another a few yards to the north to underlie the limestone. This may be easily accounted for by the original rugged and uneven surface of the limestone.

The Red Sandstone series has as its typical and most predominant rock a pink or brick-red to purple sandstone of fine to medium grain, often pebbly. The pebbles are usually small, that is ½ inch to 1 inch diameter and are composed of either pink sandstone or of white quartzite. The pebbles are as a rule sparsely distributed in the sandstone, and are frequently angular to sub-angular.

Associated with the red sandstones are clays of colours varying from grey to cherry-red, conglomerate bands and sandstones of a buff colour. The latter are in appearance very like the much later Tertiary sandstones. The clays sometimes contain thin layers of argillaceous limestone, about 1 to 3 inches thick; these show traces of fossils, mainly lamellibranchs, in the following localities:—

(1) In a tributary of the Hgehka chaung, 3 furlongs S.E. of post 33 of Mepale (Extension I) Forest; longitude 98° 29′ 40″, latitude 16° 46′ 15″.

(2) In the Hatpalu chaung, at two spots, the first 1¼ S.S.W. of Myawaddy, and the second 1½ miles S.W. by S. of Myawaddy, the two localities being not more than a half mile apart. The second locality is about ¼ mile due east of post 24 of the Mekane Forest Reserve.

The fossils from these localities are unfortunately unidentifiable, but amongst them is an *Astarte*, which has been already mentioned.

The red sandstones and clays are frequently steeply dipping or vertical, but have a moderate dip in the neighbourhood of Myawaddy.

Associated with the red sandstone is found a peculiar conglomerate composed of pebbles or boulders of limestone (Moulmein or Kamawkala Limestone) and pebbles of red sandstone in a matrix of red sandstone. As has been remarked above, an exactly similar conglomerate occurs at Kalaw in the Southern Shan States.

Calcareous Conglomerate.

This conglomerate has been found in the following places:—

In the Thaungyin river, there are eight exposures of this conglomerate over a distance (as the crow flies) of six miles, the distance being of course very much longer by water. The most southerly exposure is in latitude 16° 58′ 30″ and longitude 98° 30′ 45″. Here a boulder conglomerate is exposed as a cliff on the north (British) bank of the Thaungyin. In this bed the boulders vary from small pebbles to boulders up to 1 foot in diameter. The boulders are cemented by a matrix of red sandstone, and are of two types, that is grey limestone, obviously derived from the Kamawkala or Moulmein Limestone, and red sandstone. The derivation of the red sandstone boulders is not known. If they are derived from the Red Sandstone group, then the conglomerate would be later in age than the red sandstone. There is however no evidence of such a relationship of the conglomerates to the red sandstones. On the other hand there is no evidence of an earlier red sandstone from whence these pebbles can have been derived. The problem can only be solved by detailed mapping; meanwhile I group these conglomerates with the Red Sandstones, but with the suggestion that they may possibly be of later age or at least a high horizon in the Red Sandstones. From this outcrop the conglomerate bed appears to strike in a direction about 40° west of north. It is again seen in two exposures near the Thekaya chaung, and is of a similar type to that already described. The conglomerates are again seen in the angle of the Thaungyin about 2 miles N.N.W. of the Thekaya chaung. Again, conglomerate is found in the Thaungyin two miles to the N. W. at the mouth of the Mawpathu chaung. To the west of the confluence of the Mawpathu and Thaungyin one sees this conglomerate of Red Sandstone age, while to the east are Tertiary sands with a gentle dip. The red conglomerate dips at angles of about 60°.

Thus it would appear that there is a definite strike of this conglomerate for a distance of about six miles, this strike being parallel to the hill-ranges of the neighbourhood. The conglomerate in the northern exposure is closely associated with Kamawkala Limestone upon which it is seen in one section near the Lehpo chaung to rest. If however it is a basal bed of the red sandstones we must regard the boulders of red sandstone which it contains as coming from an unknown source. In the present state of our knowledge, it is not possible to state its relationships, but we may provisionally group it with the Red Sandstones. Another locality where a somewhat similar conglomerate was seen is the Pawhkahpu chaung at a point about 1¾ miles E.S.E. of Tawokywa. Here a conglomerate of limestone pebbles in a calcareous cement appears vaguely to dip at an angle of about 80° to west. Again in the Thapadaw chaung, not quite ¾ mile from the last mentioned spot, is a conglomerate with pebbles of red sandstone. These conglomerates were at the time referred by me to the basal Tertiaries, but it has since appeared to me more probable that they are of Red Sandstone age. But in the neighbourhood of Tawokywa, the geology is greatly obscured by the extraordinarily dense forest. Owing to the difficulties of moving about this part of the country and to the shortness of time at my disposal, I was compelled to leave the study of these conglomerates incomplete.

Tertiary Rocks; A, Basal Sands.

It has been already remarked that the Tertiary deposits fall into two divisions, a lower group of sands and boulder beds, and an upper of shales with oil-shale. The lower sandy group is extensively developed, and is found in the neighbourhood of Kamawkala gorge in the north, and in the south from Phalu to about four miles south of Phalu on the Thaungyin river. It is found forming a ring all round the Htichara basin, where it extends on both sides of the oil-shales from Tawokywa in the north to Thingannyinaung-ywathit in the south, and it occurs west of Phalu along the Forest Reserve boundary. The sands are generally loose current-bedded sands recalling those of the Irrawaddy series of Upper Burma, but fossil wood although present is very sparsely distributed in them. The wood appears to be in type very similar to that of the Irrawaddy series, and is dicotyledonous. Some large logs were seen on the banks of the Thaungyin at Phalu Forest Bungalow. The sands contain pebbles and boulders of Archæan rocks, *viz.* vein quartz, quartzites, quartz mica schists, tourmaline pegmatites, and granite gneiss. The boulders vary in size from place to place. As a rule they are smaller near the top of the sands, and larger near the base. A diameter of 1 foot is quite common in the basal strata.

But in several spots some enormous boulders were found. About two miles east of Htichara, and a furlong or so S.E. of Forest Post 33 of the Mepale (Extension 1) Forest, I saw some boulders of gneiss which were up to 8 feet in diameter. Again about 1 mile N.E. of Tawok-ywa, similar enormous boulders occur. Fairly large boulders are seen also to the west of Phalu in the Tertiary sands exposed along the Mekane Forest Boundary. In places the beds are gravels or loosely consolidated conglomerates, grading into pebbly sands or sands of more homogeneous type.

Near Tawokywa, and in the Mepale river W. and S.W. of Tawokywa, massive beds of coarse arkose and grits of a grey or buff colour are found.

In two localities, not far below the top of the basal sands, reefs of freshwater limestone are developed. The first locality is about 1½ miles E.N.E. of Htichara village. In this locality the limestone is partly silicified. It contains abundant freshwater shells. Collections were made both by Prof. J. W. Gregory in October 1921 and by myself and Mr. F. W. Walker about one month later. Both collections were sent to Dr. N. Annandale, Director of the Zoological Survey of India, who is now engaged in the description of the shells. Dr. Annandale has kindly given me a summary of his results. His provisional identifications are as follows:—

Family *Melaniidæ.*

Acrostoma intermedium sp. nov.

Acrostoma cotteri sp. nov.

Family *Viviparidæ.*

Vivipara gregoriana sp. nov.

Vivipara dubiosa sp. nov.

Family *Unionidæ.*

Indonaia bonneaudensis (Eydoux) *see* Fauna of British India Vol. Mollusca (Freshwater Gastropoda and Pelecypoda) by H. B. Preston, p. 140.

Indopseudodon rostratus sp. nov.

Lamellidens (?) *quadratus* sp. nov.

All the species are new with the exception of *Indonaia bonneaudensis*, which is still living. Dr. Annandale considers that the age of the beds cannot be precisely determined from this fauna but it obviously comes from Tertiary beds and is not very new;

there is nothing against the view that they may be Miocene, but, little in favour of such precision.

The second locality is in latitude 16° 44′ 0″ and longitude 98° 29′ 15″ about half a mile N.N.W. of the hill called Yebu Taung. This hill is one mile west of the confluence of the Mepale and Thaungyin rivers. The limestone here is somewhat silicified, and I saw no traces of fossils.

The basal sand group is easily distinguished from the oil-shale group above by the nature of the forest. The sands are covered by open dipterocarp forest, while a dense growth of bamboos covers the shale country.

The basal sands usually dip at fairly gentle angles. Near Phalu some steep dips were seen (up to 55°) in sandstone, but these were quite local.

Before I conclude my description of the Basal Sands, I may mention that the curiously large boulders of Archæan rock found in some localities near their base are comparable with those boulders of similar large size found by me in the Pleistocene deposits of Pakokku. Like the boulders of the Pakokku district, these of Amherst seem to have been carried several miles from their source.[1]

The basal sands group passes upwards conformably and somewhat gradually into the oil-shale group. The distinction between the two groups is well marked in the Htichara basin. But in the Phalu and the Mesauk-Methalaun-Melamat basin there are frequent sands associated with the upper shale group, while a freshwater shelly limestone is very frequently exposed in the shale group of the latter area. The division of the Tertiaries into two groups is here not so well marked, but still is quite recognisable.

Tertiary Rocks; B. Oil-shale group.

The group now to be described is predominantly clay and shale, but with subordinate beds of sandstone. Thin beds of limestone both of a pure and of an impure type occur, especially in the basin north of Myawaddy, which is bisected by the Thaungyin (the Mesauk-Methalaun-Melamat basin), but they are less common in the other two basins. The limestone contains traces of shells of Melaniids and Viviparids, and is clearly a freshwater deposit. The shales themselves are frequently fossiliferous, and have yielded specimens of teleostean fish, of dicotyledonous leaves, of one fern leaf, and one specimen of a spider. No attempt has been made to identify any of these specimens.

[1] *Journ. Asiat. Soc. Beng.* (New Ser.), Vol. XIV, p. 419, (1918).

Oil-shale is abundant in the lower part of this group, and occurs interbedded with barren shale. It is easily recognisable by its toughness and ability to withstand a sharp blow of the hammer without breaking, by the fact that it can be cut into shavings with a knife while barren shale crumbles to powder, by its dark grey or brown colour, and especially by the peculiar smell given out when a small splinter is heated in the flame of a match. Sometimes the oil-shale is rich enough to ignite when heated. It may occur either in thick layers or in papyraceous laminæ. There appear to be all grades of shale present from completely barren shale to high grade oil-shale. Low grade oil-shale and shales with less than 5 per cent. of volatile matter are abundant, but cannot easily be distinguished from barren shale. No trace of lignites was seen in these beds. All the evidence points to the fact that the group was laid down in fresh water. No trace of salt water fauna has been found. In one section near the base of the shale group, at the bend of the Mepale river opposite post 15 of the Mepale (Extension I) Forest boundary, (that is about 1 mile N.N.W. of the confluence of the Thingannyinaung and Mepale rivers), two thin bands of gypsum, 1 inch and ½ inch thick respectively were seen. This was the only occurrence of gypsum observed.

The country through which the shale group extends is covered with dense jungle, mainly of bamboo. There are few exposures, except in the stream sections. In reserved areas, such as the country between Tawokywa and Htichara, it is impossible to get through the forest without a most laborious process of cutting a path, while the necessity of continually walking in a stooping position is very tiring. The jungle growing upon the oil-shale group of Amherst is probably amongst the thickest found in Burma. In this respect it contrasts with the open forest of rather stunted trees found upon the lower group of basal sands.

Structure of the Tertiary basins.

In the Htichara basin, the dips are usually gentle varying from 20° to 15°. It is rather exceptional to find such a steep dip as that at Pit 1, where the angle is 30°. The dips are not however invariably oriented towards the centre of the synclinal basin, and we must suppose a certain amount of undulation in the strata. The disturbance is of a gentle type. The Phalu basin was not examined in detail, but appears to show very much more minor folding and contortion in the shale zone than is seen at Htichara. The Mesauk-

Methalaun-Melamat basin lies mainly in Siam and only touches upon British territory. The dips are generally gentle and the oil-shales are sometimes almost horizontal.

PART II—ECONOMIC GEOLOGY OF THE OIL-SHALES.

It has already been pointed out that there are three Tertiary basins in Eastern Amherst. These are Htichara, Phalu and Mesauk-Methalaun-Melemat. I visited all three, and collected, a series of samples from each. Those from the latter two basins were unfortunately reported lost in transit between Rangoon and Calcutta but as they were outcrop samples, the results would not have had great significance. From the Htichara basin, on the other hand, I was able to obtain representative samples from pits and drill cores. These were examined by Mr. H. Crookshank in the Geological Survey Office, Calcutta. Preliminary determinations were made of the volatile matter in the dried shales by the same method as is used for the proximate analysis of coal samples. The samples rich in such volatile matter were afterwards subjected to destructive distillation, and in a few instances the ammonia produced was determined at the same time. The apparatus used was designed on the lines of that used by E. L. Lomax and F. G. P. Remfry.[1] 500 grams of shale broken into pieces of smaller diameter than 1 cm. were slowly heated in a horizontal iron retort to 600°C while steam at about 150°C was passed in. The distillate was condensed in a vertical Liebig's condenser leading to a Wolff's bottle. The gases issuing from this were washed with oil to collect heavy hydrocarbon vapours, and with sulphuric acid to collect ammonia. The oil obtained from all the determinations was subjected to fractional distillation, and the results were all scaled down in accordance with the amount of water contained in this combined sample.

Testing the shale samples.

Part of the area under report has been tested with a Calyx drill by Messrs. M. E. Moola & Sons, Ltd., and the cores obtained have been examined by the Company's mining engineer, Mr. R. H. Crozier. He used a vertical electrically heated retort through which steam was passed. The distillate from 500 grams of shale was passed through air-cooled condensers, then through two water scrubbers,

Messrs. Moola's method of testing cores.

[1] *Journ. Inst. Petroleum Tech.*, Vol. VII, 36, (1921).

and through another scrubber charged with a weighed quantity of kerosene oil. Each distillation took about two hours. The water first given off was drained from the condenser and weighed; the results were then calculated on the weight of the shale used, after deducting the weight of this water. The crude oil was drained from the condenser and water scrubbers, separated as far as possible from water and weighed. Mr. Crozier's oil percentages, in my opinion, require a slight correction for water, which can be seen under the microscope in samples of the oil collected. He estimates this at 3 to 4 per cent., but it may be noted that a sample of crude oil sent from Messrs. Moola & Sons to the Geological Survey Office, Calcutta, contained 13 per cent. This, however, Mr. Crozier considers to be far beyond the average. The results of Mr. Crozier's assays, which have been kindly communicated to the Geological Survey of India by Messrs. M. E. Moola & Sons, are given in tabular form at the end of this paper.

Oil contents of the Shale.

We may now consider the nature of the oil-shales in each of the three basins. From a point about 1¼ miles north of Htichara village to one on the Mepale not quite two miles south of the village, there are numerous outcrops of oil-shale which tend to strike in a N.-S. direction. This is the area which has been drilled by Messrs. Moola & Sons. The oil-shale, which outcrops about 1¼ miles north of Htichara camp, is to be seen in the Thelamedaw chaung, and is under water in the bed of the chaung. A sample of the dried shale taken by me was analysed in the Geological Survey Office, and gave 2·59 per cent. of moisture, 49·25 per cent. of volatile matter in the dry sample and 54·41 gallons of oil per ton of shale. Another outcrop, about ¼ mile west of pit 5, showed 42·57 per cent. of volatile matter. Further south, samples were taken from four pits which had been dug by Messrs. Moola & Sons, Ltd. Of these four pits the most northerly is pit 1. This was about 13 feet deep. Three samples were taken from it, *viz.*, sample 1, or the top 2 ft. 5 ins., sample 2, or the next 6 ft. 9 ins., and sample 3, or the next lower 3 ft. 9 ins. Of these samples, sample 1 showed alternate layers of clay and shale, sample 2 was mainly oil-shale, and sample 3 was oil-shale with thin partings of clay, similar to sample 1.

Sample 1 gave 7·44 per cent. of moisture and 23·12 per cent. of volatile matter.
" 2 " 5·55 " " " 29·66 " " " "
" 3 " 6·61 " " " 29·33 " " " "

Sample No. 1 yielded 9·78 gallons of oil and 20·65 lbs. of ammonium sulphate per ton of shale.

Pit 4, about 3 furlongs to the south, is just over 25 feet deep. From this pit 4 samples were taken as follows:—

Sample 4 from a thickness of 6 ft. 4 ins., from a depth of 2 ft. to a depth of 8 ft. 4 ins.. contained 4·16 per cent. of moisture and 33·10 per cent. of volatile matter.

Sample 5 from a thickness of 8 ft. 4 ins., from a depth of 8 ft. 4 ins. to a depth of 16 ft. 8 ins., contained 3·63 per cent. of moisture and 30·09 per cent. of volatile matter.

Sample 6 from a thickness of 3 ft. 4 ins., and from a depth of 16 ft. 8 ins. to 20 ft., contained 5·28 per cent. of moisture and 30·41 per cent. of volatile matter.

Sample 7 from a thickness of 5 ft. 1 in., from a depth of 20 ft. to 25 ft. 1 in., contained 4·47 per cent of moisture and 25·09 per cent. of volatile matter.

The richest sample, No. 4, yielded 16·20 gallons of oil and 14·75 lbs. of ammonium sulphate per ton of shale.

Pit 2 lies a furlong or so east of Htichara village. The depth was over 20 ft. Three samples were taken and examined.

Sample 8, from the top 6 ft. 8 ins., contained 5·26 per cent. of moisture and 29·09 per cent. of volatile matter.

Sample 9, from a thickness of 3 ft. 9 ins., next below, contained 2·44 per cent. of moisture and 36·10 per cent. volatile matter.

Sample 10, from a thickness of 10 ft. next below, contained 3·41 per cent. of moisture and 32·06 per cent of volatile matter.

The sample richest in volatile matter, No. 9, yielded 14·44 gallons of oil and 16·68 lbs. of ammonium sulphate per ton.

The most southerly pit is pit 3, which is nearly ¾ mile south by east of Htichara. From this pit three samples were collected and tested.

Sample 11, from top to 5 ft. 8 ins., depth, contained 5·61 per cent. of moisture and 28·29 per cent. of volatile matter.

Sample 12, 3 ft. 9 ins. thick, from 5 ft. 8 ins. deep to 9 ft. 5 ins., contained 1·76 per cent. of moisture and 36·98 per cent. of volatile matter.

Sample 13, 14 ft. 7 ins. thick. from a depth of 9 ft. 5 ins. to 24 ft., contained 3·5 per cent. of moisture and 29·10 per cent. of volatile matter.

The richest sample, No. 12, yielded 25·01 gallons of oil per ton.

To the south of these pits an outcrop of oil-shale is exposed in the Mepale river just east of the junction with the Htichara stream. This yielded 17·51 gallons of oil per ton and 22·31 lbs. of ammonium sulphate. Volatile matter amounted to 34·05 per cent.

About three miles south of this last locality, there is an outcrop of oil-shale in the Thingannyinaung stream. The rock is entirely under water. A sample of this yielded only 7·94 gallons of oil per ton of shale.

The determinations reported above were made in the Geological Survey laboratory.

Method of Prospecting.

Messrs. M. E. Moola & Sons, Ltd., have drilled the country near Htichara village in the following manner :-

A strip, two miles long from north to south, and one quarter of a mile broad, has been divided into eight blocks of one square quarter mile each. At each corner of these blocks a bore has been put down to about 300 feet or less with a calyx drill. Also a bore has been put down in the centre of each block. The cores thus obtained have been analysed. Three cores were sent to Messrs. Simon Carves, one to the Geological Survey Office, Calcutta, and the rest were analysed by the Company's Mining Engineer, Mr. R. H. Crozier. The positions of the bores are shown on the map given in Plate 34. This map has been kindly supplied by Messrs. Moola & Sons.

Discussion of Mr. Crozier's assays.

From the tabular statements of Mr. Crozier's assays, given at the end of the paper, it will be observed that in bores 14, 15, 16, 17, 18, 20, 21, 22, 23, and 24 there is mention of a mark at certain depths in the midst of rich shale. This mark is a band of calcareous mudstone about 1½ inches thick and is regarded as a datum line whereby to correlate the bores in which it occurs. The persistence of this peculiar stratum throughout the bores, together with the similarity of the shales associated with it, indicates a considerable regularity in the bedding. It is unnecessary in this general description of the oil-shale area of Amherst to enter into minute detail regarding the various richer strata of oil-shale in Htichara. The figures of the analyses given above are easily intelligible to anyone who wishes to study them, and they indicate the presence of several quite rich strata of oil-shale, the richest being that associated with the mark band, the others being at various heights vertically above this mark seam. The seam associated with this mark band is about 6 to 7 feet thick and contains according to Mr. Crozier's analyses between 15 and 19 per cent. of crude oil. Underneath this thickness of six to seven feet of rich shale, the strata are considerably lower grade, but contain some oil. Thus for instance in bore 21, there is a thickness of 8 ft. 7 ins. of shale carrying 9·35 per cent. of crude oil situated 3½ feet below the rich stratum.

Above this seam, the Company have located five other seams, the position of which is shown on the map (Plate 34). These seams have been struck in the various bores listed above, and the depths at which they have been struck by the bores are indicated on the map. Thus the seam immediately above the mark seam (marked f on Plate 34), is struck in bore 23 at 93½ feet, and here we find a total thickness of 5 ft. 8 ins. of rich oil-shale, carrying 13·26 per cent. of crude oil, in 14 ft. 2 ins. of strata.

Above this, in the same bore is a seam 4 ft. 8 ins. thick, carrying 10·93 per cent. of oil. Above this, bore 19 shows three more fairly rich seams, *viz.* from a depth of 207 ft. 2 ins. to 228 ft. 6 ins. a thickness of 11 ft. 5 ins. carrying about 11 per cent. of oil associated with 5 ft. 11 ins. of lower grade shale carrying 4·21 per cent. of oil. Above this at 139 ft. 5 ins. depth there is a thickness of 12 ft. 7 ins. carrying 8·68 per cent. of oil. The highest seam shown in these bores, is low grade; there are 5½ feet of shale carrying 8·02 per cent. of oil associated with considerable thicknesses of lower grade shale. The seams above that marked f are marked a, b, c, and d on the map, seam a being the uppermost.

It is not necessary to go into further detail regarding these seams since a careful perusal of the bore records and the map will give all the information required. Enough has been said to show that *primâ facie* these oil-shales are reasonably rich in certain zones, and their economic possibilities are worthy of serious consideration.

Nature of the oil from the Htichara Oil-shales.

A sample of crude oil, forwarded to the Geological Survey Office, Calcutta, by Messrs. M. E. Moola & Sons was analysed by the Curator with the following result:—

	Per cent.
Water	13
Light naphtha (up to 150°)	4
Heavy ,, (,, ,, 150°-200°)	3
Kerosene, light and heavy to 300°	23
Lubricating oil above 300°	40
Residue above 400°	17

Messrs M. E. Moola & Sons also sent a sample to Messrs. Simon Carves, whose results were as follows :—

	Per cent.
Naphtha from gas	1·36
Light naphtha	4
Light burning oil	13
Heavy burning oil	20
Lubricating oil	43
Paraffin wax	16
Coke residue	10

Economic Value of the Oil-Shales.

The above details give what is probably a fairly accurate idea of the east flank of the Htichara basin. It now has to be considered whether these shales could be developed commercially. On the general prospects of the oil-shale industry reference may be made to the recent monographs of H. B. Cronshaw and V. C. Alderson.[1] As these works, as well as various papers in the journals connected with petroleum, discuss the general prospects of the industry, it is not necessary to say much about it here. There is however a general consensus of opinion that owing to the increased consumption of oil and the limited number of oil-fields, many of which are declining, the various deposits of oil-shale will sooner or later have to be worked. The success of the oil-shale industry in general must depend to a great extent upon the maintenance of a good price for oil; a reversion to the low prices prevailing before the war would probably render the development of a shale proposition not greatly profitable. But with a fairly high level of market prices, and reasonably low production costs, there appears no reason why a shale proposition should not pay well. Each field has its own problems and difficulties which have to be encountered and overcome. Much will also depend upon the skill and extent of the operations; a small plant is less likely to pay than one which works large quantities of shale. In the Htichara field, there appears to be a good supply of shale of a rich or fair average quality, so much in fact that it would be possible to obtain large quantities of shale by open-casting. Mining again is fairly simple; the strata dip gently, they appear to be fairly regular, the barren shales can form an excellent roof and floor, while the shales themselves would

[1] H. B. Cronshaw: "Oil Shales," (London, John Murray, 1921); V. C. Alderson: "The Oil Shale Industry", (F. A. Stokes Co., New York, 1920).

form good hard pillars. Probably retorting can be carried out by utilising the gases from the shale for heating.

Difficulties in the way of developing this area (1) the lack of communications with the sea coast; (2) the heavy rainfall and monsoon floods; (3) labour problems; (4) the various retorting and refining difficulties, some of which are very considerable, which must always be encountered in setting up a new industry in a new area. Some of these obstacles appear to be formidable, but perhaps they can be overcome.

The first difficulty, the absence of a good road or railway to Htichara, might be met by the building of a railway to Myawaddy. This route has I believe been surveyed; it is one of the trade routes to Siam, and a railway would derive some revenue from this trade as well at from the heavy non-floating timber which could be worked from the forests near Myawaddy. The railway need not be entirely dependent upon the oil-shale industry for its profits, although I am not in a position to express any opinion upon the prospects of such a railway. The second difficulty, the heavy rainfall, which occurs from July to October, may inhibit the working of open cut quarries during those months to a considerable extent.

The rainfall at Mepale has been recorded by Messrs. Steel Bros. and Co., Ltd., who have kindly furnished me with returns of rainfall for a period of ten years from 1913 to 1922. According to these statistics the average annual rainfall at Mepale is 81·1 inches that is rather less than half that of Moulmein. Although so much less than that of Moulmein, the rainfall is heavy and falls mainly between May and October. Hence the country is flooded during part of the rains, and the streams are swollen level with or over their banks. Nevertheless something might be done by a system of drainage canals. Mining also could probably be carried on. As regards the remaining difficulties, it seems premature to discuss them. On the whole, the general impression gained from a study of the subject is that the oil-shales of Htichara deserve to be seriously considered as a probable source of oil, and that there may be prospects of their successful development.

West and North Parts of Htichara basin.

The west and north parts of the Htichara basin have not been tested; all that can be done is to mention the natural outcrops of oil-shale. There are four outcrops of oil-shale in the Mepale river between Mepale and Htiwapalaw villages; these are shown on the map.

Further north there is an outcrop of oil-shale just west of Pute village on the bank of the Mepale river. Another outcrop of oil-shale is seen on the bank of the Mepale river about 1¼ miles north by east of Pute. There are also oil-shales about 3½ miles south-east of Tawokywa in the country near the junction of the Bawthalu and Pawhkahpu chaungs, and not quite half a mile east of the junction. These were the only outcrops seen, besides those already described. They indicate the presence of oil-shale all round the Htichara basin, but give us no information of the thickness, richness or extent of the oil-bearing strata. Doubtless all this area will in time be prospected.

The Phalu basin.

It is clear from the map that the greater part of the Phalu basin lies in Siam. Myawaddy itself is on alluvium, but the Jurassic Red Sandstone series outcrops quite close to the town both to the north and south. The first shales are exposed near Maw-taw tale village about 5 miles south of Myawaddy. Here in the Thaungyin river the oil-shales are well exposed. At the top of the section are three feet of fairly rich looking oil-shale, with some barren or low grade shale below, followed again by a thickness of 9 feet of not very rich looking oil-shale, but containing some rich looking bands.

South of this exposure oil shales are again seen in the Thaungyin at the 9th mile and 1th furlong on the road to Phalu. Here I saw the following section:

	Ft.	Ins
Sandy shales	5	0
Oil-shales, fairly rich in appearance	3	0
Oil shale, poor looking . .	0	6
Sand	0	6
Shale (? oil-bearing) .	0	6
Sand	0	6
Clay and shale	5	0
Sandy clay	0	6
Oil shale	2	6
Sand and shale	2	0
Sandstone	1	0

The two outcrops of oil-shale mentioned above are insufficient to give us any clear idea of the value of the Phalu basin, but if the Htichara basin is developed, it will doubtless be worth while to test this area further.

The Mesauk-Methalaun Melamat basin.

This basin which lies north of Myawaddy, and stretches as far as Kamawkala Gorge, exposes the upper oil-shale division of the Tertiary rocks in several sections east of Htichara along the Thaungyin. The northern section near Kamawkala is in the lower division of Tertiary basal sands. The most southerly exposure of oil-shales in this basin is one on the Siamese bank of the Thaungyin about 1¾ miles N. N. W. of Myawaddy. The oil-shales appear to be of a low grade quality here. For six miles to the north the Thaungyin passes through red sandstones, its course lying west of the Tertiary basin. In the latitude of Htichara, the Thaungyin turns east again, and traverses the Tertiary basin. Oil-shales are exposed on the Siamese bank ¾ mile south of the Lewa Taung, and again 1 mile east and 1¾ miles east of Lewa Taung, and further down stream, they are found 1¾ miles east by north of the Hketpulu Taung. Of these four exposures, the first shows oil-shale about 1 foot thick, the second oil-shale about 4 feet thick with 4 feet of barren strata, the fourth exposure shows about 1 foot of oil-shale. Two further exposures of oil-shale occur in the Thaungyin about 1 mile and again 2 miles below the last-mentioned locality. The first exposure shows oil-shales about 1 foot thick, the second, which is on the British bank, shows only about 6 inches of oil-shale. The next exposure of oil-shale is about 6 miles to the north at the junction of the Nvali-a chaung with the Thaungyin. The oil-shale exposed here is about 1 foot thick.

Generally the impression derived from my examination of the Thaungyin section is that the Mesauk-Methalaun-Melamat basin is not so rich in oil-shale as that of Htichara, but the best oil-shale of the basin is exposed near the Hketpulu and Lewa Taungs. One cannot however judge from the casual sections of the Thaungyin. It would appear that most of the basin lies in Siam east of the Thaungyin river. The country between Mesauk and Taung Mesauk is possibly oil-shale territory. Nevertheless, if the Htichara basin ever is developed, attention will doubtless be directed also to those other basins which lie so near, although they are less accessible. We however know little about these basins, and must at present be content with the knowledge that oil-shale does occur in the localities mentioned, and we must refrain from attempting to form any opinion at present of their economic possibilities.

Results of Analyses of Oil-shale from Borings near Htichara by Mr. R. H. Crozier.

Samples in each case have been cut in accordance with the appearance of each individual core and without reference to cores previously sampled :—

BORE No. 1. Position $\frac{A.\ 71}{5{\cdot}34}$.

Sample No.	Depth. Ft.	In.		Ft.	In.	Sample cut Ft.	In	Remarks.	Percentage of Crude oil
1	9	0	to	10	0	1	0	....	11·1
2	12	0	to	16	6	4	6	....	6·16
3	16	6	to	22	6	6	0	....	5·13
4	35	9	to	38	6	2	9	....	12·6
5	38	6	to	43	3	4	9	...	3·52
6	69	0	to	74	0	5	0	....	3·5
7	79	3	to	82	0	2	9	.	8·7
8	92	9	to	98	6	5	9	Not included in average.	2·47
9	115	9	to	117	6	1	9	....	6·28
10	147 143	0 0	to to	150 145	7 0	4	10	...	8·18
11	153	3	to	157	5	4	2	....	5·1
12	167	0	to	170	6	3	6	Hole finished 200'.	6·82

BORE No. 2. Position $\frac{B.\ 6}{3{\cdot}7}$.

Sample No.	Ft.	In.		Ft.	In.	Sample cut Ft.	In	Remarks.	Percentage of Crude oil
1	124	6	to	126	6	2	0	....	4·85
2	130	0	to	143	0	3	3	Small bands here.	

BORE No. 3. Position $\frac{A.\ 6}{4{\cdot}8}$.

Sample No.	Ft.	In.		Ft.	In.	Sample cut Ft.	In	Remarks.	Percentage of Crude oil
1	2	0	to	10	0	8	0	Excluding 1' 6" decomposed shale clay.	11·02
2	10	0	to	14	0	4	0	Not included in average.	2·2
3	14	0	to	20	6	6	6	....	9·08
4	20	6	to	28	6	8	0	....	5·01
5	31	6	to	41	6	10	0	} Not included in average.	1·25
6	76	8	to	84	8	8	0		1·80
7	94	0	to	97	6	3	6		5·06
8	106	7	to	113	0	6	5	....	5·06
9	113	0	to	118	7	5	7	....	11·55
10	144	0	to	146	0	2	0	....	5·11

BORE NO. 3—*contd.*

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
11	166 6 to 171 0	4 6	....	3·6
12	185 0 to 186 6	1 6	....	8·8
13	191 6 to 197 0	5 6	....	6·34
14	199 6 to 204 0	4 6	.....	10·52
15	204 0 to 207 0	3 0	....	3·1
16	230 6 to 233 11	3 5	Balance of cores slipped to Simon Carves for analysis.	3·58

BORE NO. 4. Position $\frac{A. 5}{6 \cdot 13}$

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
1	13 0 to 19 6	6 6	....	5·12
2	24 0 to 27 0 31 0 to 39 0	11 0	....	10·0
3	19 6 to 24 0 27 0 to 31 0 39 0 to 44 0	13 6	....	4·8
4	44 0 to 55 0	11 0	....	3·6
5	55 0 to 57 0	2 0	... .	8·33
6	58 0 to 70 6	12 6	Not included in average	2·2
7	80 6 to 85 6	3 0	....	5·7
8	79 3 to 86 6	1 3	....	3·8
9	90 0 to 94 0	2 0	....	8·13
10	94 0 to 97 0	3 0	....	4·0
11	103 0 to 104 0 105 6 to 107 9	3 3	....	4·0
12	120 9 to 124 0 128 4 to 132 1	7 3	....	5·45
13	146 0 to 157 3	11 3	....	6·66
14	166 0 to 177 6	11 6	....	3·5
15	185 0 to 189 4	4 4	....	3·66
16	213 3 to 215 0 216 6 to 219 6 224 6 to 227 0 228 3 to 229 9	8 9	....	14·38
17	210 0 to 213 3 215 0 to 216 6 219 6 to 221 6 227 0 to 228 3	11 0	Intermediate lower grade bands of sample 16.	5·13
18	232 0 to 235 6	3 6	....	7·04
19	279 0 to 281 0	2 0	....	4·43
20	294 0 to 296 0	2 0	....	6·61

BORE No. 7. Position A.

Sample No.	Depth. Ft. In. to Ft. In.	Sample cut. Ft. In.	Remarks.	Percentage of Crude oil.
1	24 9 to 34 9	10 0	....	3·66
2	34 9 to 39 7 42 2 to 43 2	5 10	....	3·5
3	44 10 to 48 2	3 4	....	2·97
4	57 4 to 65 0	7 8	....	2·68
5	65 0 to 76 0	11 0	Sample includes 15" small limestone bands which could be excluded in mining.	7·94
6	86 11 to 90 3	3 4	....	3·22
7	95 0 to 102 4	7 4	....	2·13
8	113 0 to 117 4	3 6	....	8·47
9	125 0 to 128 6	3 6	....	5·14
10	153 9 to 159 10	6 1	....	5·45
11	168 0 to 170 4	2 4	....	7·65
12	171 8 to 174 0	2 4	....	5·48
13	175 8 to 177 6 178 0 to 181 11 182 0 to 184 0	7 6	....	5·55
14	194 8 to 202 0	7 4	....	5·01
15	205 0 to 208 6	3 6	....	7·03
16	220 6 to 225 0	4 6	....	3·25
17	225 0 to 231 0	6 0	....	2·55
18	231 6 to 235 0	3 6	....	6·98
19	238 6 to 247 0	8 6	....	6·3
20	256 0 to 261 0	4 6	....	2·75
21	263 0 to 268 0	5 0	Not included in average.	1·71
22	268 0 to 270 6	2 6	....	7·78
23	277 0 to 281 0	4 0	....	5·7

BORE No. 8. Position

Sample No.	Depth. Ft. In. to Ft. In.	Sample cut. Ft. In.	Remarks.	Percentage of Crude oil.
1	27 5 to 28 0 29 6 to 31 0	2 1	....	4·9
2	32 6 to 36 6	4 0	....	3·05
3	40 3 to 45 10	5 7	....	6·0
4	46 7 to 48 9	2 2	Not included in average.	1·19
5	73 6 to 75 0 77 4 to 81 6	5 8	....	2·46
6	81 10 to 85 6	3 8	....	3·49
7	116 6 to 118 0 118 6 to 121 6	4 6	....	3·12
8	126 10 to 129 4	2 6	....	5·14
9	134 2 to 135 4 137 0 to 140 0	4 2	....	3·49

BORE NO. 8—*contd.*

Sample No.	Depth.					Sample cut.		Remarks.	Percentage of Crude oil.
	Ft.	In.		Ft.	In.	Ft	In.		
10	155	10	to	158	4	2	6	....	13·6
11	163	4	to	166	10	3	6	....	9·09
12	167	4	to	173	4	6	0	....	4·8
13	180	8	to	185	4	4	8	....	3·3
14	199	4	to	202	8	3	4	Not included in average.	1·48
15	203	1	to	206	0	2	8	....	8·75
16	214	6	to	216	6	2	0	....	4·2

BORE NO. 9. Position $\frac{A.\ 25}{4\cdot25}$.

Sample No.	Depth Ft.	In.		Ft.	In.	Sample cut Ft.	In.	Remarks.	Percentage of Crude oil.
1	58	1	to	62	5	4	0	....	3·86
2	78	8	to	80	10	3	2	....	6·29
	81	8	to	82	8				
3	86	0	to	88	6	2	6	6" Band hard yellow limestone.	10·00
4	90	8	to	94	11	4	3	....	5·09

BORE NO. 13 (Supplementary to Bore No. 9).

Sample No.	Depth Ft.	In.		Ft.	In.	Sample cut Ft.	In.	Remarks.	Percentage of Crude oil.
1	9	0	to	15	0	6	0	White marl.	20·4
2	20	4	to	23	9	1	2	....	14·7
	27	0	to	27	9				
3	23	9	to	27	0	3	10	...	5·3
	27	9	to	28	4				
4	46	8	to	50	6	3	10	....	8·92
5	50	6	to	53	8	3	2	..	2·69
6	103	8	to	106	3	3	7	....	6·45
	107	0	to	108	0				
7	113	3	to	115	3	5	3	....	7·15
	116	0	to	119	3				
8	153	10	to	155	10	2	0	....	10·55
9	158	10	to	162	10	4	0	....	3·7
10	189	4	to	196	8	7	4	...	3·6
11	196	10	to	200	0	3	2	....	4·0
12	204	4	to	208	6	4	2	....	3·2
13	216	6	to	218	0	3	0	....	3·7
	219	6	to	221	0				
14	225	7	to	227	1	1	6	....	20·0
15	233	1	to	234	9	1	8	....	8·91
16	241	1	to	245	4	4	10	....	5·05

BORE No. 10. Position A. 5

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
1	34 0 to 35 0	1 10	....	16·17
2	42 4 to 44 5	2 1	....	4·12
3	44 5 to 48 6	4 1	....	7·62
4	48 6 to 52 4	4 10	....	3·45
5	52 4 to 56 0	3 8	....	9·52
6	56 0 to 58 6	2 6	....	3·24
7	79 2 to 81 2	2 0	....	4·39
8	113 3 to 114 3 120 4 to 122 6	3 2	....	4·5
9	114 3 to 119 6	5 3	Two white limestone bands 2″ and 5″ wide.	19·16
10	126 3 to 130 10 131 8 to 133 9	6 8	....	11·19
11	125 9 to 126 3 130 10 to 131 8 133 9 to 135 3	2 10	....	3·76
12	148 9 to 152 0	3 3	....	3·5
13	152 0 to 155 0	3 0	....	9·4
14	155 0 to 158 3	3 3	....	3·11
15	172 6 to 177 6	5 0	Not included in average.	1·6
16	187 0 to 191 1	4 1	....	7·75
17	210 5 to 214 8	4 3	....	5·12
18	222 1 to 224 5 218 3 to 221 9	5 7	....	6·72
19	264 4 to 265 10	1 6	....	15·05
20	269 9 to 272 9	3 0	....	4·9

BORE No. 11. Position $\frac{\text{A. 25}}{4{\cdot}75}$.

1	19 9 to 21 4	1 7	....	11·81
2	28 0 to 32 0	4 0	....	5·57
3	32 0 to 34 9	2 9	....	3·19
4	34 9 to 39 4	4 7	....	14·96
5	40 4 to 46 4	6 0	....	2·95
6	59 9 to 63 3	3 6	....	4·07
7	78 11 to 82 0	3 1	....	4·57
8	94 7 to 101 3	6 8	Shows 1 + 2″ white limestone bands.	17·35
9	93 0 to 94 7 101 3 to 103 0	3 4	....	3·7

BORE NO. 12. Position $\frac{A.\ 5}{4\cdot5}$

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
1	15 0 to 16 6 17 0 to 22 4	6 10	....	4·56
2	23 8 to 29 0	5 4	....	8·69
3	56 6 to 58 0	1 6	....	8·86
4	60 0 to 61 2	1 2	....	3·03
5	71 4 to 72 6 74 4 to 76 9	3 7	....	5·12
6	92 0 to 93 6	1 6	....	10·46
7	99 8 to 103 0	4 4	....	8·64
8	103 0 to 106 6	3 6	....	3·9
9	106 6 to 110 8	4 2	...	14·66
10	112 2 to 116 0	3 10	....	2·42
11	134 11 to 137 11	3 0	....	5·68
12	155 0 to 156 3	1 3	....	5·46
13	156 3 to 160 0	3 9	....	3·76
14	168 0 to 170 6	2 6	....	5·37
15	170 6 to 177 3	6 9	2″ white band at 175′ 2″.	17·45
16	177 3 to 182 2	4 11	....	3 41
17	182 2 to 185 7 188 9 to 191 0	5 8	2″ white band at 186′ 7″.	12·96
18	185 7 to 188 9 191 0 to 192 3	4 5	....	3·88
19	208 2 to 211 6	3 4	....	10·19
20	211 6 to 216 0	4 6	....	3·21
21	229 8 to 231 3	1 7	....	3·34
22	265 9 to 267 9	2 0	....	2·97
23	268 10 to 273 0	3 2	....	5·14
24	276 0 to 279 10	3 10	....	7·0
25	280 6 to 284 0	3 6	....	4·17
26	285 0 to 289 8	3 8	....	0·7
27	243 0 to 243 6 245 9 to 250 4	5 1	....	5·05

BORE NO. 14. Position $\frac{A.\ 25}{4\cdot75\ (2)}$.

1	19 7 to 21 1	1 6	....	10·87
2	27 1 to 34 8	7 7	....	5·57
3	34 8 to 39 2	4 6	....	11·33
4	41 0 to 43 2	2 2	Not included in average.	1·63
5	58 8 to 61 2	2 6	....	5·76

BORE No. 14—*contd.*

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
6	93 9 to 101 3	7 6	Shows white mark at 99′ 4″.	15·11
7	101 3 to 106 0	4 9	....	2·94
8	106 8 to 109 6	4 3	....	14·0
	112 7 to 114 0			
9	106 0 to 106 8	4 10	....	4·63
	109 6 to 112 7			
	114 0 to 115 1			
10	132 4 to 139 1	6 9	....	6·41
11	130 1 to 132 4	3 3	Not included in average.	1·23
	139 1 to 140 1			
12	152 10 to 158 8	5 10		2·64
13	164 8 to 165 8	6 8		0·7
	167 0 to 172 8			
14	173 8 to 184 8	11 0		1·9
15	185 10 to 190 6	5 4	....	3·0
	194 0 to 194 8			
16	190 6 to 194 0	3 6	....	6·8
17	197 8 to 200 8	3 0	....	9 0
18	201 6 to 206 8	5 2	....	5·7
19	229 6 to 231 3	4 3	..	3·14
	232 9 to 235 3			
20	241 5 to 245 3	3 10	....	6·4
21	247 4 to 251 1	3 9	....	4·6
22	271 5 to 279 0	7 7	..	5·9
23	283 2 to 287 10	4 8	....	4·8
24	288 5 to 290 8	6 8	..	3·0
	291 5 to 295 10			

BORE No. 15. Position A./4.

1	2 4 to 4 0	5 2	10″ Clay band 4′ 4″-10″. Mark at 6′ 6″.	18·81
	4 10 to 8 4			
2	8 4 to 13 8	5 4	....	2·9
3	13 8 to 17 0	3 4	....	12·9
4	17 0 to 21 1	3 1	....	3·1
5	22 11 to 25 1	2 2	....	10·3
6	101 0 to 102 0	4 10	....	4·6
	102 10 to 106 3			
	106 7 to 107 0			

BORE NO. 16. Position $\frac{A.}{5 \cdot 5}$

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
1	14 11 to 15 8 22 4 to 23 11	2 4	....	9·2
2	27 0 to 30 0	3 0	....	13·14
3	81 1 to 87 5	6 4	Mark at 85′ 7½″.	16·94
4	92 4 to 100 2	7 10	....	8·44
5	91 0 to 92 4 100 2 to 101 8	3 0	....	2·09
6	116 2 to 120 2	4 0	....	7·48
7	120 2 to 123 9	3 7	....	3·72

BORE NO. 17. Position $\frac{A.\ 25}{5 \cdot 25}$

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
1	13 5 to 15 0 18 8 to 19 4 21 8 to 22 8 26 0 to 28 0	5 11	....	5·02
2	34 9 to 35 1 37 5 to 38 5 41 8 to 44 0	3 8	....	15·72
3	34 4 to 34 9 35 1 to 35 7 38 5 to 41 8 44 0 to 45 0	5 2	....	7·00
4	49 8 to 50 1 50 4 to 54 8	4 9	....	12 5
5	47 3 to 49 8 50 1 to 50 4 54 8 to 59 0	7 0	....	3·7
6	59 0 to 61 9	2 9	....	9·7
7	66 9 to 68 9	2 0	....	4·23
8	95 1 to 99 7	4 6	....	4·0
9	115 5 to 119 10	4 5	....	5·6
10	129 1 to 133 3	4 2	....	4·41
11	133 3 to 139 1	5 10	....	8·44
12	161 4 to 162 11 165 7 to 166 5	2 5	....	5·72
13	182 10 to 188 3	5 5	....	4·49
14	205 0 to 206 5	1 5	....	9·61
15	213 4 to 219 0	5 8	....	6·68
16	220 0 to 224 0	4 0	....	14·04
17	243 7 to 247 9	4 2	....	3·31
18	260 7 to 266 7	6 0	Mark at 261′ 5″.	17·01
19	266 7 to 271 7	5 0	....	2·57
20	271 0 to 273 6	2 6	....	13·11

BORE NO. 18. Position $\frac{A.\ 25}{5{\cdot}75}$.

Sample No.	Depth. Ft. In. to Ft. In.	Sample cut. Ft. In.	Remarks.	Percentage of Crude oil.
1	8 7 to 12 3	3 8	....	4·15
2	17 3 to 22 0	4 8	....	3·91
3	22 10 to 26 10	3 0	...	3·63
4	27 5 to 29 6	2 1	....	14·74
5	35 0 to 47 11 }	14 7	....	8·0
	48 3 to 49 11 }			
6	69 1 to 72 11	3 10	....	3·87
7	91 10 to 96 5	1 7	....	5·31
8	105 0 to 109 5 }	9 9	.. .	6·79
	110 2 to 112 0 }			
	112 5 to 115 11 }			
9	133 3 to 134 7 }	2 4	....	6·17
	136 10 to 137 10 }			
10	155 1 to 160 4	5 3	.. .	4·66
11	173 4 to 174 4 }	4 0	....	8·85
	180 4 to 183 4 }			
12	186 0 to 190 6	4 6	....	18·43
13	190 6 to 195 0	1 6	....	3·38
14	208 0 to 211 7	3 7	....	3·91
15	244 0 to 250 11	6 11	Marl	15·97

BORE NO. 19. Position $\frac{A.\ 5}{6{\cdot}5}$

Sample No.	Depth. Ft. In. to Ft. In.	Sample cut. Ft. In.	Remarks.	Percentage of Crude oil.
1	11 0 to 16 6	5 6	....	8·02
2	16 6 to 22 10	6 4	....	5·19
3	23 9 to 25 10	2 1	....	5·56
4	25 10 to 35 1	9 3	..	4·44
5	35 1 to 42 4	7 3	....	6·66
6	42 4 to 47 4 }	7 8	....	6·44
	48 9 to 51 5 }			
7	53 7 to 58 4	4 9	....	5·31
8	65 0 to 67 5	2 5	....	8·44
9	70 6 to 75 3	1 9	....	4·97
10	81 9 to 84 9	3 0	....	3·22
11	84 9 to 87 9	3 0	....	5·54
12	95 10 to 97 8	1 10	....	8·05
13	104 8 to 109 2	4 6	....	4·63
14	118 0 to 121 8	3 8	....	5·11
15	124 6 to 129 10	5 4	....	5·08
16	139 5 to 152 0	12 7	....	5·68
17	159 2 to 161 3 }	2 9	....	6·40
	165 10 to 166 6 }			
18	176 2 to 179 6	3 4	....	4·63
19	195 3 to 199 9	4 6	....	3·26

Bore No. 19—*contd.*

Sample No.	Depth. Ft. In. to Ft. In.	Sample cut. Ft. In.	Remarks.	Percentage of Crude oil.
20	207 2 to 210 4	6 5	....	11·11
	211 10 to 215 1			
21	210 4 to 211 10	5 11	...	4·21
	215 1 to 219 6			
22	219 6 to 222 4	5 0	....	10·95
	223 10 to 226 0			
23	222 4 to 223 10	4 0	....	4·39
	226 0 to 228 6			
24	228 6 to 231 6	3 0	....	10·35
25	231 6 to 239 7	8 1	....	3·25
26	320 11 to 324 7	3 8	....	4·63

Bore No. 20. Position $\frac{A.\ 25}{6{\cdot}25}$.

Sample No.	Depth. Ft. In. to Ft. In.	Sample cut. Ft. In.	Remarks.	Percentage of Crude oil.
1	2 2 to 2 9	10 9	....	10·33
	9 11 to 20 1			
2	23 9 to 27 0	3 3	....	3·12
3	59 10 to 62 5	2 7	Not included in average.	2·58
4	73 9 to 76 0	2 3	....	6·15
5	86 0 to 91 11	5 11	....	3·91
6	91 11 to 99 0	7 1	....	7·04
7	115 8 to 117 8	2 0	....	10·25
8	140 0 to 141 6	5 9	....	6·86
	145 4 to 146 9			
	149 0 to 151 10			
9	151 10 to 152 10	5 9	....	12·76
	155 9 to 160 6			
10	160 6 to 169 6	7 0	....	5·00
	166 0 to 168 0			
11	196 7 to 203 9	7 2	Mark 201′ 10″.	15·04
12	209 5 to 212 2	4 1	....	12·61
	214 8 to 216 0			
13	195 9 to 196 7	8 0	2′ 8″ core lost. Actual core 5′ 4″.	6·28
	205 9 to 209 5			
	212 2 to 214 8			
	216 0 to 217 0			

Bore No. 21. Position $\frac{A.}{8}$.

Sample No.	Depth. Ft. In. to Ft. In.	Sample cut. Ft. In.	Remarks.	Percentage of Crude oil.
	6 7 to 9 0	4 2	....	6·07
	13 4 to 14 1			
	19 0 to 20 0			
2	23 4 to 31 2	7 10	....	6·33
3	42 6 to 43 7	3 5		5·09
	53 0 to 55 4			

BORE NO. 21—*contd.*

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
4	62 4 to 63 5			
	65 3 to 66 5	3 0	....	4·35
	71 9 to 72 6			
5	79 2 to 79 10			
	81 4 to 82 5			
	84 7 to 86 10	9 1	...	15·87
	92 4 to 94 2			
	94 6 to 96 7			
	100 2 to 101 2			
6	79 10 to 81 4			
	82 5 to 84 7	9 6	....	5·91
	86 10 to 92 4			
	94 2 to 94 6			
7	140 1 to 142 6	7 5	....	6·6
	151 0 to 156 0			
8	156 0 to 161 11	5 11	....	10·91
9	171 3 to 172 1			
	174 6 to 174 9	3 5	....	7·38
	184 9 to 185 9			
	187 5 to 188 9			
10	197 3 to 199 5	2 2	....	6·50
11	201 5 to 207 10	6 5	...	8·43
12	207 10 to 213 9	5 11	....	13·20
13	252 6 to 259 0	6 6	Mark at 254′ 5″.	19·14
14	262 7 to 271 2	8 7	....	9·35
15	251 2 to 252 6	4 11	...	4·40
	269 0 to 252 7			

BORE NO. 22. Position $\frac{A.}{6{\cdot}5}$

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
1	11 0 to 12 4			
	21 9 to 22 9	6 11	....	10·84
	28 1 to 32 8			
2	48 6 to 50 0	1 6	....	9·59
3	70 0 to 74 9	4 9	....	4·74
4	89 3 to 89 8			
	93 7 to 95 3	5 6	....	13·40
	99 11 to 103 4			
5	89 8 to 93 7	8 0	....	5·29
	95 3 to 99 11			
6	124 9 to 126 3	1 6	....	4·54
7	143 5 to 147 9	3 4	....	4·05
8	159 7 to 167 4	7 9	Mark at 165′ 3″.	16·84
9	173 2 to 181 2	8 0	....	10·77
10	167 4 to 173 2	5 10	....	4·36

BORE No. 23. Position $\frac{A.}{7}$.

Sample No.	Depth. Ft. In. to Ft. In.	Sample cut. Ft. In.	Remarks.	Percentage of Crude oil.
1	18 4 to 21 2	2 10	....	6·01
2	21 2 to 25 4	4 2	....	3·41
3	30 2 to 36 10	6 8	...	5·27
4	36 10 to 41 6	4 8	.	10·93
5	51 9 to 57 0	5 3	....	4·88
6	69 4 to 72 7	3 3	...	6·52
7	83 3 to 83 8 89 0 to 90 4 93 6 to 97 5	5 8	....	13·26
8	87 6 to 89 0 90 4 to 93 6 97 5 to 101 6	80 9	....	4·56
9	111 4 to 115 7	4 3	...	3·91
10	126 8 to 129 9 132 8 to 133 8	4 1	...	4·41
11	140 2 to 146 11	6 9	Mark at 115′	17·69
12	151 3 to 156 6	5 3	...	10·22
13	146 11 to 151 3 156 6 to 159 4	7 2	..	3·49

BORE No. 21. Position $\frac{A.}{7 \cdot 5}$.

Sample No.	Depth. Ft. In. to Ft. In.	Sample cut. Ft. In.	Remarks.	Percentage of Crude oil.
1	3 10 to 4 7 6 7 to 8 10 10 5 to 10 10 12 7 to 14 0 20 2 to 21 8 22 11 to 24 5	7 10	....	6·73
2	8 10 to 9 5 10 10 to 11 9 14 0 to 15 2 19 2 to 20 2 24 5 to 25 11 27 1 to 27 4	5 5	....	15·46
3	58 2 to 60 8	2 6	....	4·69
4	80 3 to 84 5	4 2	....	7·12
5	84 5 to 90 5	6 0	...	10·37
6	99 11 to 103 8	3 9	....	5·97
7	115 10 to 120 5	4 7	....	5·05
8	128 10 to 130 0 133 8 to 138 1	5 7	....	10·48
9	140 3 to 144 3	4 0	....	14·25
10	130 0 to 133 8 138 1 to 140 3 144 3 to 147 0	8 7	Not included in average.	2·79

BORE NO. 24—*contd.*

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
11	158 8 to 162 2	3 6	....	3·66
12	187 11 to 194 6	6 7	Mark at 192′ 9″.	18·72
13	200 5 to 202 10 205 1 to 206 7	3 11	. .	15·10
14	186 11 to 187 11 194 6 to 200 5 202 10 to 205 1	9 2	....	4·75

BORE NO. 25. Position $\frac{A.\ 25}{6\cdot75}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
1	12 0 to 12 10 13 8 to 14 11 16 5 to 17 10	3 6	...	10·72
2	10 10 to 12 0 12 10 to 13 8 14 11 to 16 5 17 10 to 23 11	9 7	Core from 15′ 3″ to 15′ 8″ lost.	6·26
3	33 0 to 33 6 34 10 to 36 0 38 0 to 41 2	4 10	...	5·05
4	49 1 to 52 4 55 6 to 56 8	4 5	....	4 33
5	61 9 to 65 8	3 11	....	4·82
6	68 11 to 75 7	6 8	Core from 71′ 10″ to 73′ 1″ lost.	4·17
7	82 9 to 84 6 88 0 to 90 10	4 7	....	16·78
8	81 2 to 82 9 84 6 to 88 0 90 10 to 94 7	8 10	Core from 87′ to 87′ 8″ lost.	5·95
9	94 7 to 100 4 104 6 to 106 11	8 2	....	11·63
10	100 4 to 104 6	4 2	....	4·16

BORE NO. 26. Position $\frac{A.\ 25}{7\cdot25}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
1	8 2 to 9 6	1 4	....	5·01
2	14 9 to 21 2	6 5	Core 15′ to 17′ lost.	3 77
3	30 10 to 32 10	2 0	Core 31′ 8″-32′ 2″ lost.	0·83
4	37 6 to 39 10	2 4	....	6·91
5	52 6 to 62 11	10 5	Core 53′ 6″-55′ 6″ lost, and 59′ 4″-60′ lost.	8·75

BORE NO. 26—*contd.*

Sample No.	Depth. Ft. In. to Ft. In.	Sample cut. Ft. In.	Remarks.	Percentage of Crude oil.
6	69 5 to 71 5 75 5 to 76 10	3 5	....	6·84
7	116 4 to 116 8 118 6 to 119 9 122 1 to 125 4	4 10	...	17·46
8	116 8 to 118 6 116 9 to 122 1	4 2		4·18
9	129 2 to 131 3 133 8 to 134 11 138 0 to 139 9	5 1	..	12 68
10	131 3 to 133 8 134 11 to 135 7	3 1	..	7 31
11	125 4 to 129 2 135 7 to 138 0	6 3	...	4 18

BORE NO. 27. Position A. 5

Sample No.	Depth. Ft. In. to Ft. In.	Sample cut. Ft. In.	Remarks.	Percentage of Crude oil.
1	10 6 to 11 8 13 1 to 13 6 14 11 to 15 4	2 0	...	7·39
2	11 8 to 13 1 13 6 to 14 11	2 10	..	2 09
3	31 1 to 35 10	4 9	...	6·53
4	35 10 to 39 5 43 8 to 45 5	5 4	..	8 83
5	75 0 to 78 0 81 0 to 83 0	5 0	...	3·55
6	91 9 to 98 6	6 9	Missing from 97′ 5″-98′ 1″.	6·65
7	111 7 to 117 4	5 8	....	5·43
8	127 8 to 130 1 133 4 to 136 0	5 1	....	89·2
9	136 0 to 146 2	10 2	Missing 137′ 10″-; 142′ 1″-142′ 6″.	6·46
10	146 2 to 153 2	7 0	....	4·73
11	152 2 to 158 7	5 5	....	7·59
12	158 7 to 170 5	11 10	....	6·16
13	170 5 to 175 7	5 2	...	4·61
14	175 7 to 181 2 186 8 to 189 5	8 4	....	10 59
15	181 2 to 186 8	5 6	....	2·59
16	192 2 to 197 8	5 6	....	5·25
17	204 8 to 208 2	3 6	....	4·17
18	208 2 to 211 2	..	....	

BORE NO. 28. Position $\frac{\text{A. 25}}{7{\cdot}75}$

Sample No.	Depth.					Sample cut.		Remarks.	Percentage of Crude oil.
	Ft.	In.		Ft.	In.	Ft.	In.		
1	5	7	to	8	2	6	1	....	3·79
	10	0	to	13	6				
2	25	6	to	29	6	4	0	....	2·20
3	33	5	to	35	5	2	0	....	9·21
4	38	0	to	46	9	8	9	Missing 39′ 3″-42′.	3·29
5	56	2	to	64	6	8	4	....	4·12
6	73	3	to	81	0	7	9	....	7·74
7	81	0	to	85	5	4	5	....	5·81
8	91	9	to	94	9	4	9	....	6·66
	98	9	to	100	6				
9	136	10	to	144	4	7	6	....	14·29
10	144	4	to	151	4	10	6	....	5·78
	152	4	to	155	10				
11	151	4	to	152	4	3	3	...	12·98
	155	10	to	158	1				

EXPLANATION OF PLATES.

PLATE 34.—Sites of Borings near Hticliara. Scale 8″ = 1 mile.

PLATE 35.—Geological Map of Eastern Amherst. Scale 4″ = 1 mile.

PROVISIONAL LIST OF PALÆOZOIC AND MESOZOIC FOSSILS COLLECTED BY DR. COGGIN BROWN IN YUN-NAN. BY F. R. COWPER REED, SC.D., F.G.S.

A series of papers dealing with the geological results of his explorations in Yun-nan has been published by Dr. Coggin Brown in the *Records* of the Geological Survey of India during the last ten years, and there are references in their pages to the discovery of fossils at many localities.[1] The specimens have been entrusted to me for determination, and a Memoir dealing with them will appear in due course in the *Palaeontologia Indica*.[2] Although the manuscript is nearly ready for the press, it is thought that in the meanwhile a provisional list of the fossils providing the palæontological evidence for the occurrence of the various stratigraphical horizons would be useful to other workers in Yun nan and in neighbouring areas. It is interesting to find in the present collection rich faunas of Lower Carboniferous and Permo-Carboniferous age possessing the same general characters as those already described by Mansuy and others in Eastern Asia. There is also a noticeable occurrence of a Devonian fauna from one locality. Attention should also be drawn to the abundant Upper Triassic fauna of Miao-tsway which exhibits somewhat the same characters as that of the Nucula marls of the Sunda Islands and of the Padang beds of Sumatra. The Namyau beds of Bathonian age, which occur in the Northern Shan States, are also represented in another locality and have yielded a typical series of fossils.

LIST OF FOSSILS.

CAMBRIAN.

Lo-chia-ying, (K12·242).[3]

Redlichia cf. *chinensis* Walcott.

[1] See *Rec., Geol. Surv. Ind.*, Vol. XLIII, pp. 173–205, pp. 327–334, (1913); Vol. XLIV, pp. 385—422, (1914); Vol. XLVII, pp. 205—266, (1916); Vol. LIV, pp. 68–86, 296–323 and 323—340, (1922).

[2] It should be pointed out that Dr. Cowper Reed has already described in detail the Ordovician and Silurian fossils collected by me in Yun nan. See *Pal. Ind.*, new ser., Vol. VI, Mem. No. 3, (1917). J. Coggin Brown.

[3] These numbers refer to those under which the fossils are registered in the books of the Geological Survey of India.

ORDOVICIAN.

Pupiao, (K17·558).

Caryocrinus sp.

DEVONIAN.

4½ miles from Chin-chiang-kai, Yung-pe route, (K17·531)

Favosites cognata sp. nov.
Pachypora aff. *polygonalis* Mansuy.
Striatopora retardata sp. nov.
Amplexus yunnanensis sp. nov.
Crinoidal remains.
Orthis cf. *bistriata* Tscherr
,, aff. *Gervillei* Defr.
Chonetes plebeia Schnur. var. nov. *plurilineata.*
,, *sarcinulata* Schloth. var nov. *yungpeensis*
Spirifer sp. a.
,, sp. b.
Atrypa desquamata Sow.
Conocardium sp.
Jovellania sp.
Orthoceras sp.
Sphyradoceras ? sp.
Proetus mediospinosus sp. nov.

LOWER CARBONIFEROUS.

Ta-shih-wo, (K11·987-994) and (K12·235)

Nodosaria sp.
Reniera sp.
Syringopora intermixta sp. nov.
Amplexus sp.
Campophyllum cf. *caninoides* Sibly.
Caninia aff. *Nikitini* Stuck.
,, aff. *Lonsdalei* Keys.
Cyathophyllum fraternum sp. nov.
,, *sororium* sp. nov.
Fischerina insolita sp. nov.
,, *solitaria* sp. nov.
Rhodophyllum elusum sp. nov

Histiophyllum occultum sp. nov.
Cyclophyllum sp.
Poteriocrinus sp.
Fenestella aff. *laxa* Phill.
,, sp.
Glauconome aff. *bipinnata* Phill.
Rhombopora cf. *bigemmis* Keys.
Orthis (*Rhipidomella*) *Michelini* Lev.
,, (*Schizophoria*) aff. *resupinata* Mart.
Schellwienella crenistria (Phill.)
Leptæna analoga Phill.
Productus yunnanensis Loczy.
,, ,, var.
,, *cora* D'Orb. var.
,, *longispinus* Sow.
,, *muricatus* Phill. var. nov. *paucispinosa.*
,, (*Pustula*) *impersonatus* sp. nov.
Chonetes cf. *crassistria* McCoy.
,, *papilionacea* (Phill.)
Spirifer bisulcatus (Sow.) var. *trigonalis* Mart.
,, ,, var. *Kleini* Fischer.
,, *duplicicosta* Phill. var.
,, *tornacensis* De Kon.
,, aff. *calcaratus* McCoy.
Spiriferina cristata Schloth. ?
Loxonema sp.
Phillipsia spinifera sp. nov.

Sow-wa-shu, (K11·977-K11·979).
Sponge spicules.
Zaphrentis sp.
Bothrophyllum sp.
Campophyllum sp.
Syringopora sp.
Crinoidal remains.
Fistulipora sp.
Schellwienella crenistria (Phill.)
Orthis (*Schizophoria*) cf. *resupinata* Mart.
Chonetes sp.
Productus yunnanensis Loczy ?

Straparollus ? sp.
Euomphalus ? sp.

Ho-shiu-tang, (K11·983, 984).
Textularia sp.
Bigenerina sp.
Trochammina sp.
Chætetes subradians Mansuy ?
Rhodophyllum ? sp.
Histiophyllum ? sp.
Clisiophyllum sp.

Si-yang road, (K12·240).
Michelinia siyangensis sp. nov.

Si-yang gorge. (K12·241).
Dysodonta Deprati Mansuy.
Parallelodon cf. *obtusus* (Phill.).
Edmondia aff. *Goldfussi* De Kon.

Talu-Wei-sha route, (K17·535).
Syringopora mekongensis sp. nov.
Reticularia indica Waag. var. nov. *yunnanensis*
Leperditia viator sp. nov.
,, *Okeni* Munst. var. nov. *intumescens.*
,, *subæqualis* sp. nov.
,, sp.
Bairdia cf. *mucronata* Reuss.

Ta-huang-ti and Man-mu route, (K17·540).
Nodosaria sp.
Cyathophyllum sp.
Aviculopecten (*Pterinopecten*) sp.
Murchisonia sp.

Fang-ma-chang, (K11·996), (K17·569).
Hemitrypa sinensis sp. nov.
Polypora cf. *fastuosa* De Kon.
,, sp.
Rhombopora sp.
Crinoidal remains.

UPPER CARBONIFEROUS.

Tzu-men-lu, (K12·236).
Neoschwagerina craticulifera (Schwager).
Fusulina cf. *montipara* Ehrenb.

Nakoli-Pu-erh-Fu, (K17·548).
Endothyra sp.
Valvulina sp.
Bigenerina sp.
Fusulina sp.
Climacammina ? sp.
Trochammina ? sp.
Neoschwagerina sp.
Geodites sp.

Yang-lin road, (K12·239).
Fusulina sp.
Endothyra sp.
Reniera ? sp.

Tang-chi, (K12·237).
Fusulina sp.
Endothyra sp.
Cribrospira sp.
Reniera sp.
Haplistion ? sp.
Sollasia cf. *Dussaulti* Mansuy.
,, ? sp.
Araeopora ramosa Waag. & Wentz.
Menophyllum ? sp.
Orthis (*Rhipidomella*) aff. *Pecosi* Marcou
Spirifer (*Martinia*) *tangchiensis* sp. nov.
,, (,,) sp.
Athyris (*Spirigerella subtriangularis* sp. nov.
Microdoma ? *parvituberculata* sp. nov.
Naticopsis ? sp.

Eul-kai, (K12·233).
Campophyllum vigilans sp. nov.
Productus ? sp.

Streptorhynchus aff. *pelargonatus* Schloth.
Athyris (*Seminula*) cf. *subtilita* Hall.
" (") *eulkaiensis* Mansuy ?
Spirifer sp.
Euomphalus (*Schizostoma*) cf. *catillus* Mart.
Pleurotomaria (*Mourlonia* ?) *eulkaiensis* sp. nov.
Bellerophon (*Waagenella*) sp.

CARBONIFEROUS, (Lower or Upper).

Yen-tsu-shao, (K12·238).
Indet. foraminifera.
Dibunophyllum ? sp.
Spirifer (*Martiniopsis*) *orientalis* Tschern. var.
Porcellia ? sp.

Between Mong-chu and Ping Chang, (K17·566).
Archimedes ? sp.
Indet. foraminifera.
Crinoidal remains.

East of Yung-chang Fu plain, (K17·570)
Phillipsia (*Proetella* sp. nov.) *cognata* sp. nov.

Wan-chia-tien, (K17·552).
Zaphrentis ? sp.
Campophyllum aff. *Schrenki* Stuck.

Yunnan-i, (K17·554).
Haplistion ? sp.
Amplexus ? sp.
Amphipora aff. *socialis* Roman.

Between La-meng and Tai-ping-tzu, (K17·550).
Lithostrotion ? sp.

Ta-wang-miao, (K17·556).
Endothyra ? sp.

Western side of Pu-piao plain, 2 miles from village, (K17·557).

Indet. coral.
Chonetes ? sp.

Tsin-niu-kai, (K17·54), K17·567).

Geodites ? sp.
Indet. gastropods

Than-say, (K11·981).

Fenestella sp.
Crinoidal remains.

Ta-huang-ti—Nahsai route, (K17·539).

Indet. foraminifera.

Range to east of Yung-pe valley, Sinchang route, (K17·555)

Amphipora sp.

Pass to Kai-tou, (K12·243).

Chonetes hardrensis Phill. ?

Talu—Wei-sha, (K17·560).

Amphipora asiatica sp. nov.
Heliolites sp.

Tsin-tsun (K12·234).

Alveolites ? Thomsoni sp. nov.
Dibunophyllum sp.
Uralinia ? sp.

PERMO-CARBONIFEROUS.

Ta-li-shao, (K12·231).

Michelinia yunnanensis sp. nov.
Syringopora ? sp.
Zaphrentis sp. 1.
,, sp. 2.
,, sp. 3.
Poteriocrinus cf. *maschatensis* Roman.
,, sp.

Crinoid stem, type 1.
,, type 2.
,, type 3.
,, type 4.
Fenestella assumpta sp. nov.
,, *elusa* sp. nov.
,, sp.
Rhombopora ? sp.
Thamnicella orientalis sp. nov.
Acanthoclema ? sp.
Geinitzella sp.
Orthotichia Morgani (Derby).
Derbya cf. *grandis* Waag.
Productus semigratiosus sp. nov.
,, *tenuistriatus* De Vern.
,, cf. *cora* D'Orb.
,, (*Pustula*) *pustulatus* Keys.
,, (,,) *Abichi* Waag.
,, (,,) *Waageni* Rothpl. var.
,, sp.
Strophalosia proxima sp. nov.
Chonetes pseudovariolata Nik. var. nov. *yunnanesis.*
,, *Molengraaffi* Broili.
,, cf. *geinitziana* Waag.
,, aff. *transitionis* Krot.
,, sp.
Athyris (*Cleiothyridina*) *roissyana* Keys.
,, cf. *timorensis* Rothpl.
,, (*Actinoconchus*) sp.
Spirifer fasciger Keys.
,, *Fritschi* Schellw. var. nov. *peregrina.*
,, *rajah* Dav.
,, *Schellwieni* Tschern. var.
,, aff. *carnicus* Schellw.
,, cf. *tastubensis* Tschern.
,, cf. *varuna* Dien.
,, (*Martiniopsis*) *talishaoensis* sp. nov.
,, (,,) cf. *chidruensis* Waag
,, (,,) sp.
Reticularia sublineata sp. nov.

Notothyris ? sp.
Camarophoria aff. *Purdoni* Dav.
Rhynchopora ? *emerita* sp. nov.
Aviculopecten hiemalis Salt. var. nov. *alta*.
,, cf. *Deprati* Mansuy.
,, aff. *Kokscharovi* De Vern.
Palæolima scabrosa sp. nov.
Modiola yunnanensis sp. nov.
Parallelodon [*Macrodon*] cf. *multistriatus* Girty.
,, [,,] cf. *tenuistriatus* Meek.
Conocardium aff. *Rouxi* Mansuy.
,, ? sp.
Pleurotomaria ? sp.
Bellerophon ? sp.

Ta-u-shao, (K12·232).
Productus cf. *Cancrini* De Vern.
,, sp.
Spirifer (*Martinia*) cf. *simensis* Tschern
,, (*Martiniopsis* ?) sp.

Ta-'ı-shao, (K17·562).
Productus cf. *plano-hemisphærium* Netsch
Spirifer (*Martinia*) *bellistriatus* sp. nov.

TRIAS.

Ping-chang and Ta-hi-ti, (K17·542).
Encrinus liliformis Miller.
Near Ping-chang (K17·543, K17·544).
Protrachyceras ladinum Mojs.
,, cf. *Reitzi* (Boeckh).
Cœlostylina (*Gradiella*) cf. *semigradata* Kittl.
Pecten cf. *discites* Schloth.
Posidonia cf. *wengensis* Wissm.

Miao-tsway (K11·963, K11·970).
Pecten Nerei Munst. var.
,, (*Syncyclonema*) *subsecutus* sp. nov.
Lima cf. *Telleri* Bittn.
,, aff. *austriaca* Bittn.

Avicula aff. *arcuata* Munst.
Mysidioptera cf. *incurvostriata* Gumb.
,, *paucicostata* sp. nov.
Gervilleia Krumbecki sp. nov.
,, aff. *planata* Broili.
Cassianella cf. *Verbeeki* Krumb.
,, cf. *gryphæata* Munst.
,, cf. *bidorsata* Munst.
Halobia aff. *tropitum* Kittl.
Myoconcha ? sp.
Cucullæa (*Macrodon*) cf. *impressa* Munst.
Leda [*Nuculana*] *yunnanensis* sp. nov.
,, [,,] *perlonga* Mansuy.
,, [,,] aff. *sulcellata* Munst.
Nucula strigillata Goldf.
,, ,, var. nov. *extensa*.
,, *misolensis* Jaworski.
,, *subæquilatera* Schafh. var. nov. *tswayensis*.
,, *subobliqua* D'Orb.
Palæoneilo præacuta Klipst.
Cardita (*Palæocardita*) cf. *buruca* (Boehm.).
,, ,, *globiformis* Boettger, var. nov. *Healeyi*.
,, ,, *Mansuyi* sp. nov.
,, cf. *trapezoidalis* Krumb.
Myophoria Verbeeki (Boettg.) var. nov. *curta*.
,, *Mansuyi* sp. nov.
,, cf. *Volzi* Frech.
,, aff. *fissidentata* Wöhrm.
Myophoricardium cf. *lineatum* Wöhrm ?
Pachycardia rugosa Hauer.
Pomarangina ? cf. *cassiana* Bittn.
Rhætidia aff. *Zitteli* Bittn.
Athyris [*Spirigera*] ? sp.

Beyond Huang-lo-chai, (K17·547).
Trachyceras (*Sirenites*) sp.
Ptychites ? sp.
Cœlostylina aff. *Heeri* Kittl.
Scurria delicata sp. nov.
Cassianella gryphæata Munst. var. *tenuistria* Munst.

Gervillia præcursor Quenst. var. nov. *protracta.*
Pinna aff. *lima* Boehm.
Gonodon cf. *Mellingi* (Hauer).
Cardita aff. *singularis* Healey.
Cardium sp.

Yunnan-i, (K11·971, K11·973-K11·975).
Halobia yunnanensis sp. nov.
,, *pluriradiata* sp. nov.
Hoferia sp.
Leda [*Nuculana*] sp.
Palæoneilo suborbicularis sp. nov.
Buchites ? sp.

Manmu-Naku route, (K17·537).
Pecten aff. *quotidianus* Healey.
Lima (*Plagiostoma*) cf. *nuda* Parona
Gervillia cf. *præcursor* Quenst.
,, cf. *shaniorum* Healey.
,, cf. *sancti-galli* Stopp.
,, *nakuensis* sp. nov.
Modiola cf. *frugi* Healey.
,, aff. *raibliana* Bittn.
,, sp.
Anodontophora manmuensis sp. nov.
,, cf. *ovalis* Parona.
Myophoriopsis (*Pseudocorbula*) ? sp.
Myoconcha cf. *gastrochæna* (Dunk).
Pleuromya ? sp.
Cardium ? sp.

Near Ta-shan-shio, (K17·538).
(1) Soft greenish mudstone.
Pecten aff. *subalternans* D'Orb.
Gonodon cf. *Mariani* Tomm.
Anodontophora cf. *griesbachi* Bittn.
Palæoneilo aff. *elliptica* Goldf.
(2) Shaly mudstone.
Daonella cf. *Lommeli* Wissm.

(3) Grey limestone.
Thecosmilia aff. *fenestrata* Reuss.
Alveopora ? sp.
Spiriferina ? sp.

JURASSIC, (BATHONIAN).

Two miles below Liu-wun, on the Lu-chiang—Fang-ma-chang route, (K17·536).

Rhynchonella (*Burmirhynchia*) *adjudicata* sp. nov.
" " *conjurata* sp. nov.
" " *præstans* sp. nov.
" " *tenuiplicata* sp. nov.
" " *luchiangensis* sp. nov.
" " " var.
" (*Cryptorhynchia* ?) sp.
Terebratula (*Holcothyris*) *angusta* Buckm.
" " *flexa* Buckm.
" " *pinguis* Buckm. var. nov. *luchiangensis*.
" " " var. nov. *olivæformis*.
" " " var nov. *longisulcata*.
Ostrea cf. *acuminata* Sow.
" (*Exogyra*) cf. *auriformis* Goldf.
" " *subrostrata* sp nov.
Pecten (*Camptonectes*) cf. *lens*. Sow.
" cf. *wollastonensis* Lyc.
Lima aff. *cardiiformis* Sow.
Gervillia ? sp.
Cucullæa cf. *cucullata* Goldf.
Hippopodium cf. *rhomboidale* Phil.
Cypricardia sp.
Pholadomya ? sp.

JURASSIC, (HORIZON DOUBTFUL).

Bottom of ascent to Tai-ping-tzu, (K17·553).
Pecten aff. *annulatus* Sow.
Exogyra sp.

Waldheimia ? sp.
Rhynchonella ? sp.

JURASSIC OR TRIASSIC.

Between Ta-hi-ti and Man-mu, (K17·568).
Thecosmilia ? sp.
Phyllocœnia ? sp.

OF DOUBTFUL STRATIGRAPHICAL REFERENCE.

(Fossils indeterminable).

(*a*) Ta-huang-ti—Man-mu, (K17·541).
(*b*) 300 feet above the Salween between La-meng, and Tai-ping-tzu, (K17·559).
(*c*) 12½ miles from Shun-kia-tsun, Chi-ta-na route, (K17·559).
(*d*) Above Ping-chang (K17·546).

NOTE ON THE FALL OF THREE METEORIC IRONS IN RAJPUTANA ON THE 20TH MAY 1921. BY L. LEIGH FERMOR, O.B.E., D.SC., A.R.S.M., F.A.S.B., F.G.S. *Superintendent, Geological Survey of India.* (With Plates 36 to 38.)

I—GENERAL REMARKS.

IN the year 1907 I published a paper entitled 'Notes on some Indian Aerolites' [1], containing accounts of the circumstances attendant upon the fall, and of the external characteristics of specimens, of four Indian aerolites, followed by notes on five other falls. A list of meteoritic falls recorded in India up to 1905 is given. The total was 71, of which all but three (Nedagolla, Kodaikanal, and Lodhran) were stony meteorites or aerolites; and of these 71 all except Goalpara and Kodaikanal were seen to fall. It was suggested that during the twentieth century at least one fall a year within the limits of the Indian Empire would be reorded.

Since 1905, *i.e.*, in 16 years, 22 fresh falls have been recorded, so that the expected average has been realised. In addition an earlier fall (Kamsagar) has been recorded, so that the total of Indian falls including two earlier finds (Assam and Singhur) now stands at 96, of which three are irons, - for one of the latest falls (Samelia, 1921) is a siderite —— and two are siderolites (including Singhur).

For the sake of convenience these 25 falls are listed below in chronological order :—

Date of fall.	Name of fall.	Described.
1846 (found)	Assam	W. von Haidinger See G. T. Prior, Catalogue, p. 9, (1923).
1847 (found)	Singhur	H. Grand see prior *i.e.*, p. 166.
1902, Nov. 12	Kamsagar	J. Coggin Brown, *Rec.*, XLV, pp. 223-225,
1906, Dec. 15	Vishnupur	G. de P. Cotter, *Rec.*, XLII, pp. 265-277.
1907, May 9	Chainpur	″
1910, Jan. 7	Mirzapur	″
1910, Sep. 15	Baroti	″
1910, Sep. 19	Khohar	″
1910, Nov. 24	Lakangaon	″

[1] *Rec., Geol. Surv. Ind.*, XXXV, pp. 79-95, (1907).

Date of fall.	Name of fall.	Described.
1911, Jan. 22	Tonk (Chhabra.)	W.A.K. Christie, *Rec.*, XLIV, pp. 41-51.
1912, April	Shupiyan	J. Coggin Brown, *Rec.*, XLV, pp. 221-223.
1913, Jan. 12	Banswal	J. Coggin Brown, *Rec.*, XLIII, pp. 237-248.
1914, April 6	Kuttipuram	J. Coggin Brown, *Rec.*, XIV, pp. 209-221.
1915, Jan. 19	Visooni	H. Walker, *Rec.*, XLVII, pp. 273-279.
1916, April 5	Ekh Khera	H. Walker, *Rec.*, XLVII, pp. 273-279.
1916, July 10	Sultanpur	H. Walker, *Rec.*, LIV, pp. 133-142.
1916 Nov. 21	Rampurhat	H. Walker, *Rec.*, LIV, pp. 133-142.
1917, Feb. 20	Ranchapar	H. Walker, *Rec.*, LIV, pp. 133-142.
1917, July 23	Cranganore	H. Walker, *Rec.*, LIV, pp. 133-142.
1919, May 1	Adhikot	
1920, Aug. 30	Merua	
1920, Dec. 23	Atarra	
1921, Jan. 17	Haripura	
1921, May 20	Samelia	
1921, Sept. 9	Shikarpur	

Accounts of the first 17 falls have been given by Drs. Coggin Brown, Christie, and Cotter, and Mr. H. Walker, in the volumes of the *Records of the Geological Survey of India* indicated; the remaining 6 are still undescribed, but the falls have been recorded in the General Reports of the Geological Survey of India for the years 1919, 1921, and 1922, respectively.[2]

It is proposed in the present paper to place on record as before the circumstances accompanying the fall of the most remarkable of these new acquisitions, namely the three siderites of the Samelia fall, together with an account of the characteristics thereof.

II—THE SAMELIA METEORITE.

Although over three hundred siderites or meteoric irons and siderolites are now known to science, very few of these have been seen to fall, the remainder having been found lying on the surface, or discovered by ploughing, quarrying, road building and gold washing operations, etc., at depths up to 32 feet from the surface.

[2] H. H. Hayden, *Rec., Geol. Surv. Ind.*, LI, p. 7, (1920).
L. L. Fermor, *Op. cit.*, LIV, p. 10, (1922).
E. H. Pascoe, *Op. cit.*, LV, p. 9, (1923).

The number of siderites and siderolites of which the fall has been recorded, as given in Dr. G. T. Prior's catalogue of meteorites published by the British Museum in 1923, is 23 siderites, and 6 siderolites, of which one siderite (Nedagolla) and one siderolite (Lodhran) are Indian.

Great interest attaches, therefore, to the fall of three meteoric irons in Rajputana on the 20th May 1921. Two of these siderites fell in the jungles of Samelia (25°40′, 74°52′) and Beshki (25°39′ 74°53′) about 7 miles W. N. W. of Shahpura, in the Chiefship of the same name, and the third in the village of Beskalai (74°47′, 25°39′) in the Banera Estate of Mewar, lying immediately to the west of the Shahpura Chiefship. Through the kind offices of the Political Agent, Haraoti and Tonk, and of the Resident in Mewar, and the generosity of the Kamdar of Shahpura, and of the Raja Sahib Bahadur of Banera, these meteorites are now in the collection of the Geological Survey of India. The principal account of the circumstances of this fall is given in a letter from the Kamdar of Shahpura and the Political Agent, Haraoti and Tonk, by whom the fall was first brought to our notice. This account states :—

"On the afternoon of the 20th May 1921, at about 5-30 P.M. a meteor, like a radiant globe, appeared in the sky running from south to north and leaving a white trail in the sky but it disappeared after a quarter of an hour. The globe burst at last thundering like a volley of guns when several pieces like melted iron are said to have dropped down on the earth. Two of these pieces fell in the Shahpura Chiefship one weighing one seer 2½ chattaks. The other weighing 10½ chattaks."

The account given of the fall in Banera territory states :—

"It fell from the sky accompanied by a loud report produced by the clashing of clouds. It looked like a red hot piece. As it fell it entered the ground to the depth of seven inches".

The weights of the three meteoric irons are as follows :—

170.A Samelia 1125·36 grammes.
170.B Beshkalai 749·51 grammes.
170.C Beshki 586·88 grammes

The specific gravities of these three irons have been found to be 7·831, 7·858, and 7·826, respectively.

According to the 1 inch sheet No. 38 of the Rajputana Topographical Survey, Beshki is about 1¼ miles S.S.E. of Samelia; Beshkalai is not marked on this map, but judging from the coordinates as given in a letter from the Mahakma Khas, Udaipur, to the Resident in Mewar, this village must be close to the village of Dantal and some 5 miles west of Beshki. The distribution of the siderites does not throw much light on the direction of flight, but it is worth noticing that the heaviest piece was found at the most northerly locality, as would be expected if the flight were from south to north as stated.

Brief descriptions of each specimen may now be given.

170. A. Found at Samelia.

This siderite is of irregular angular shape, which will be realised better from the photographs (Plate 36) than from any description. It shows several straightish edges and one triangular face, which presumably bear some relation to the internal crystallographic structure. Except along some of the edges, where the bright metal is exposed, the siderite is almost completely covered with a thin black crust, generally smooth as seen with the naked eye, but showing under the lens a net-work of fine raised lines, which often lie roughly at right angles to the edges, as if caused by the rush of air over these edges acting on the thin molten crust. In places where the flow ridges are fewer or absent the crust is stippled with minute raised points. At one or two corners the metal has been slightly hammered, presumably out of curiosity by the finder. There are a few minute cracks in the meteorite and occasional depressions that tend to be holes and suggest that the siderite when sliced may prove to contain a small proportion of some substance additional to the nickel-iron of which it otherwise appears to be composed.

170. B. From Beshkalai.

This is the specimen found (at Beshkalai) in the Banera estate. Its very irregular shape is shown in the photographs (Plate 37). The irregular surface is again no doubt an index to the internal structure and several of the depressions approximate to the triangular. The crust is very similar to that of 170.A and shows under the lens the same flow lines and stippled points. There are also a few minute cracks, and at certain corners the iron has been slightly hammered. One corner appears to have been broken off subsequent to the formation of the main crust, but prior to arrival at the earth's surface : for the fractured surface reveals a parallel laminated structure in the metal; with the edges of the laminæ slightly fused over.

170. C. From Beshki.

This siderite is much less perfect than the the two preceding. One edge is very crude and appears to have been broken during flight subsequent to the formation of the main crust, and, as in 170.B, to have been partially fused over, though not sufficiently so to hide completely the laminated structure of the metal. One end of this edge has been severely damaged artificially by filing or hammering. Near the other end of this edge is a right-angled depression showing the basset edges of the laminæ of the metal dipping at about 60° to the edge between the two faces of the right angle. The crust itself is, on one side of the meteorite, considerably thicker than on 170 A and 170.B, and the fusion lines on this portion of the crust are much coarser than on the other siderites and are easily visible to the naked eye. The remainder of the crust is smoother, but with "thumb marks", indicating the direction of the flight; this portion of the crust is thinner than the portion of the crust referred to above, and may be of later age. (Plate 38.)

Although there is no reason for doubting that these three meteoric irons form one fall yet an inspection of the photographs will show at once that there are differences in general aspect. Thus the angularity of 170.A is on a much larger scale than that of 170.B, whilst 170.C is more rounded and less angular than either, with an approximation in appearance towards the "thumb-marked" aspect of some stony meteorites and with the flow lines over a portion of the crust on a much coarser scale than in 170.A and 170.B. A consideration of these facts, with the meteorites before one, drives one to the conclusion that the parent mass was, at the time of entry into the earth's atmosphere, of some magnitude, and that the metal was more coarsely crystallised (170.A) in one part than in another (170.B). The rounding of 170.C and its much thicker crust on one side than elsewhere and than in 170.A and 170.B, and its more evident signs of fusion in the thicker crust, suggest that this siderite was derived from the outer portion of the parent siderite. Similarly the facts that 170.A and 170.B have a much thinner crust and are more angular than 170.C indicate probably that the former were derived from the interior of the parent siderite at the time of disruption and that fracture followed, as might be expected, the lines of crystallographic cleavage; and also that the duration of the flight through the earth's atmosphere subsequent to disruption was insufficient to permit of the same degree of rounding of edges and angles by fusion as characterised the surface of the parent siderite before disruption.

As these three meteoric irons have not yet been sliced, it is not possible at present to give an account of their chemical composition and internal structure. Indeed, it is perhaps doubtful whether it is in the interest of science to cut up any of these specimens, carrying on their surface, as they appear to do, clues to their recent advenres.

This siderite is, as already noted, the twenty-fourth of which the fall has been observed. Omitting the two aerolites, Assam and Goalpara, the siderolite Singhur and the siderite Kodaikanal, the fall of which was not observed, we have now records of the fall in India between 1798 and 1921 of 89 aerolites, 2 siderites and 1 siderolite. This is not a very dissimilar proportion from that for the world as a whole as deducible from Dr. Prior's catalogue of meteorites up to 1922, namely 417, 24 and 6.[1] The small proportion of siderites and siderolites to aerolites doubtless has some simple explanation that will one day be forthcoming.[2]

But accepting it as a fact we must regard the 302 siderites recorded in Dr. Prior's catalogue as found up to 1922 as the accumulated falls of a thousand years or more. The siderolites being composed partly of stony materials, have not been so easily preserved and the 30 specimens recorded in Dr. Prior's catalogue as found up to 1922 represent probably an accumulation of a few centuries only.

[1] Including the meteorites listed in the present paper.

[2] Whether we suppose that meteorites are fragments of the earth torn off at the time of departure of the moon, or fragments loosed from the parent body of the solar system at the time of its tidal disruption by near approach of another stellar body [See my paper "Preliminary note on the Origin of Meteorites," *Journ. A. S. B., N. S.*, Vol. VIII, p. 322, (1922)] it seems reasonable to anticipate that a higher proportion of the fragments of the stony crust of the primordial body than of the metallic interior would be flung off into space

EXPLANATION OF PLATES.

Plate 36.—Iron meteorite found at Samelia.
Plate 37.— " " " " Beshkalai.
Plate 38.— " " " " Beshki.

MISCELLANEOUS NOTE.

On a Crystal of Monazite from Simultala.

The monazite crystal described below was presented to the Presidency College, Geology Department by Mr. A. T. Bose, M.Sc., who picked it up as a stray specimen, (not *in situ*), near Simultala.

It is a portion of a single crystal and measures 2.8×2.4×1.1 c.m. The colour is reddish-brown, inclining to black in places. The lustre is resinous but pearly on cleavage faces. Sp. Gr.=5·22. In thin sections the colour is yellow. The crystal shows absorption lines of didymium earths with a direct-vision spectroscope.

The faces of the crystal are so dull that the angles could not be measured with a reflection goniometer. A contact goniometer was therefore used.

The following forms are developed—a (100), m (110), w (101), x ($\bar{1}01$), c (001) and v (111). The rare form c (001) is conspicuously developed here, and the crystal has an extremely perfect cleavage parallel to this face.

In colour, lustre and specific gravity it resembles the Pichhli (Gaya) crystals described by G. H. Tipper.[1] The crystal is, however, tabular, parallel to a (100), which in this case is the dominant form.

SARATLAL BISWAS.

BHUPENDRANATH MAITRA.

[1] *Rec., Geol. Surv. Ind.*, Vol. L. (1919), p. 259 *et seq.*

INDEX TO RECORDS, VOLUME LV.

SUBJECT.	PAGE.

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Fig 1

Records, Vol. LV, Pl 37

Fig 1

K I Watkinson, Photos

Fig 2

IRON METEORITES

G S I Calcutta

Records, Vol LV, Pl. 38

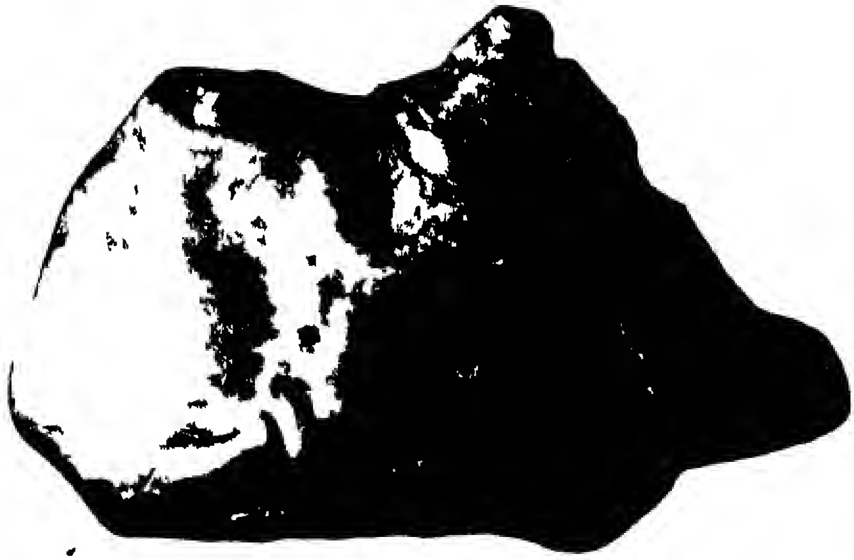

Fig 1

Fig 2

K F Watkinson, Photos

G S I. Calcutta

IRON METEORITES

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1924 [August

THE MINERAL PRODUCTION OF INDIA DURING 1923. BY

E. H. PASCOE, M.A., SC.D. (CANTAB.), D.SC. (LOND.), F.G.S., F.A.S.B., *Director, Geological Survey of India.*

CONTENTS.

INTRODUCTION.

THE method of classification adopted in the first Review of Mineral Production published in these Records (Vol. XXXII) although admittedly not entirely satisfactory, is still the best that can be devised under present conditions. As the methods of collecting the returns become more precise and the machinery employed for the purpose more efficient, the number of minerals included in Class I—for which approximately trustworthy annual returns are available—increases, and it is hoped that the minerals of Class II—for which regularly recurring and full particulars cannot be procured—will in time be reduced to a very small number. In the case of minerals still exploited chiefly by primitive Indian methods, and thus forming the basis of an industry carried on by a large number of persons, each working independently and on a very small scale, the collection of reliable statistics is impossible, but the total error from year to year is not improbably approximately constant and the figures obtained may be accepted as a fairly reliable index to the general trend of the industry. In the case of gold, the small indigenous alluvial industry contributes such an insignificant portion to the total outturn that any error from this source may be regarded as negligible.

The average value of the Indian rupee during the year 1923 was 1*s.* $4\frac{9}{32}$*d.*; the highest value reached was 1*s.* $5\frac{1}{4}$*d.*, and the lowest 1*s.* $3\frac{15}{16}$*d.* The values shown in table 1 and all following tables of the present Review are given on the basis of 1*s.* 4*d.* to the rupee.

From table 1 it will be seen that there has been an apparent increase of over £1,200,000 or about 5 per cent. in the value of the total production over that of 1922. The value figures, however, are somewhat artificial. In some instances, although the output has fallen in quantity, it has increased in value; such increase does not necessarily give a true indication of the state of an industry.

The number of mineral concessions granted during the year amounted to 624 against 672 in the preceding year; of these one was an exploring license, 513 were prospecting licenses and 110 were mining leases.

TABLE 1.—*Total value of minerals for which returns of Production are available for the years 1922 and 1923.*

——	1922 (Rupee = 1*s.* 4*d.*)	1923 (Rupee = 1*s.* 4*d.*)	Increase.	Decrease.	Variation per cent.
	£	£	£	£	
Coal . . .	9,755,343	9,738,569	..	16,774	—0·2
Petroleum . . .	7,202,494	7,007,915	..	194,579	— 2·7
Manganese-ore(*a*).	915,428	2,215,984	1,300,556	..	+142·1
Gold . .	1,857,577	1,702,642	..	154,935	— 8·3
Carried over .	19,730,842	20,665,110	1,300,556	366,288	+130·9

(*a*) f. o. b. value at Indian ports.

TABLE 1.—*Total value of minerals for which returns of Production are available for the years 1922 and 1923*—contd.

—	1922 (Rupee—1*s*. 4*d*.)	1923 (Rupee—1*s*. 4*d*.)	Increase.	Decrease.	Variation per cent.
	£	£	£	£	
Brought forward	19,730,842	20,665,110	1,300,556	366,288	+130·9
Lead and lead-ore	945,137	1,121,474	176,337	..	+18·7
Salt	744,966	749,382	4,416	..	+0·6
Silver	675,234	677,207	1,973	..	+0·3
Mica (*b*)	385,683	538,435	152,752	..	+39·6
Building materials	394,833	512,409	117,576	..	+29·7
Tin and tin-ore	188,963	185,641	..	3,322	—1·8
Saltpetre	234,866	149,757	..	85,109	—36·2
Iron ore	104,428	136,415	31,987	..	+30·6
Jadeite (*b*)	124,811	55,803	..	69,008	—41·6
Chromite	24,086	51,119	27,033	..	+112·2
Ruby, Sapphire and Spinel	48,487	48,679	192	..	+0·4
Tungsten-ore	25,035	31,979	6,944	..	+27·7
Clays	16,900	21,356	4,456	..	+26·4
Magnesite	16,046	15,622	..	424	—2·6
Zinc-ore (*b*)	90,505	11,584	..	78,921	—87·2
Phosphate	1,133	5,388	4,255	..	+375·6
Ochre	3,805	4,461	656	..	+17·2
Copper ore	20,509	4,367	..	16,142	—78·7
Alum	6,651	4,298	..	2,353	—35·4
Fuller's earth	2,451	3,811	1,360	..	+55·9
Monazite	1,871	3,697	1,826	..	+97·6
Bauxite (*c*)	1,063	3,682	2,619	..	+246·4
Steatite	2,432	3,290	858	..	+35·3
Diamonds	6,110	3,100	..	3,010	—49·3
Barytes	3,200	2,850	..	350	—10·9
Ilmenite	1,200	2,100	900	..	+75·0
Soda	68	1,600	1,532	..	.
Zircon	1,280	1,160	..	120	—9·4
Gypsum	1,315	1,156	..	159	—12·1
Amber	131	915	784	..	..
Asbestos	701	659	..	42	—6·0
Hyalite	..	352	352	.	..
	23,804,742	25,018,858	1,839,364	625,248	+4·8
			+1,214,116		

(*b*) Export values.
(*c*) Excludes the value of 932 tons.

II.—MINERALS OF GROUP I.

Chromite.	Iron.	Manganese.	Ruby, Sapphire and Spinel.	Silver.
Coal.	Jadeite.	Mica.	Salt.	Tin.
Copper.	Lead.	Monazite.	Saltpetre.	Tungsten.
Diamonds.	Magnesite.	Petroleum.		Zinc.
Gold.				

Chromite.

There was a very large increase in the production of Chromite which rose from about 22,800 tons in 1922 to over 54,200 tons in the year under review. This increase was mainly due to greater mining activity in the Mysore State.

TABLE 2.—*Quantity and value of Chromite produced in India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee= 1*s.* 4*d.*)		Quantity.	Value (Rupee= 1*s.* 4*d.*)	
	Tons.	Rs.	£	Tons.	Rs.	£
Baluchistan—						
Quetta-Pishin .	..	..	..	1,257	6,364	424
Zhob . . .	18,548	2,88,227	19,215	23,062	3,39,453	22,630
Bihar and Orissa—						
Singhbhum .	1,147	15,660	1,044	914	11,977	798
Mysore—						
Hassan . .	2,120	38,160	2,544	25,604	3,68,262	24,551
Mysore . .	962	19,240	1,283	3,405	40,735	2,716
Total .	*22,777*	*3,61,287*	*24,086*	**54,242**	*7,66,791*	*51,119*

Coal.

There was an increase during the year of some 646,800 tons, or about 3·4 per cent., in the output of coal. This increase was due chiefly to Bihar and Orissa and Bengal, but Hyderabad and Central India also contributed. The Central Provinces shewed a decrease of nearly 19 per cent., and the outputs from Assam and Baluchistan were also considerably reduced; the Punjab shewed a slight decrease. The increase in Bihar and Orissa was due to the two great fields of Jharia and Raniganj, to the recovery of the Giridih field and to the steady expansion of Bokaro. The maiden effort of the Talcher seams, which have been referred to in previous reviews, amounted to some 4,800 tons. The Sasti field of Hyderabad again shews a considerable decline which, however, is more than balanced by the partial recovery of the Singareni field. The Sohagpur field of Central India nearly doubled its production, but Umaria continued its decline. Ballarpur and the Pench valley were chiefly responsible for the serious drop in the Central Provinces output. The new Loi-an coalfield of Burma, which is of Gondwana and not of Tertiary age as formerly supposed, has made strides during the year and increased its output from 172 tons in 1922 to just over 2,000 tons in 1923.

The pit's mouth value of coal decreased in some areas and increased in others. In Burma it increased another 5 rupees or so, as it had done the previous year, and the rate in Baluchistan rose nearly Rs. 1-7-0. In the Punjab the drop in value amounted to Rs. 4-14-0, in the Central Provinces to Re. 1 and in Rajputana to Re. 0-4-5. Bengal and Bihar and Orissa both shew an average decrease, the presidency of Re. 0-8-4 and the province of Re. 0-1-10.

TABLE 3.—*Average Price (per ton) of Coal extracted from the mines in each province during the years 1922 and 1923.*

	1922.	1923.
	Rs. A. P.	Rs. A. P.
Assam	8 5 4	8 11 1
Baluchistan	13 7 5	14 14 4
Bengal	9 10 1	9 1 9
Bihar and Orissa	6 15 5	6 13 7
Burma	16 0 0	21 3 3
Central India	5 13 6	5 13 0
Central Provinces	7 10 7	6 10 7
Punjab	14 13 10	9 15 10
Rajputana	7 2 2	6 13 9

TABLE 4.—*Origin of Indian Coal raised during 1922 and 1923.*

—	Average of last five years.	1922.	1923.
	Tons.	Tons.	Tons.
Gondwana coalfields	19,490,848	18,520,513	19,218,284
Tertiary coalfields	434,487	490,473	439,494
Total	**19,925,335**	**19,010,986**	**19,657,778**

TABLE 5.- *Provincial Production of Coal during the years 1922 and 1923.*

Province.	1922.	1923.	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.
Assam	348,103	326,149	..	21,954
Baluchistan	60,135	42,562	..	17,573
Bengal	4,328,986	4,621,578	292,592	..
Bihar and Orissa	12,711,328	13,212,250	500,922	..
Burma	172	2,166	1,994	..
Central India	161,231	175,950	14,719	..
Central Provinces	675,916	548,074	..	127,842
Hyderabad	642,880	658,429	15,549	..
Punjab	67,180	63,501	..	3,679
Rajputana	15,055	7,119	..	7,936
Total	**19,010,986**	**19,657,778**	**825,776**	**178,984**

TABLE 6.- *Output of the Gondwana Coalfields for the years 1922 and 1923.*

	1922.		1923.	
	Tons.	Per cent. of Indian total.	Tons.	Per cent. of Indian total.
Bengal, Bihar and Orissa—				
Bokaro	1,037,171	5·46	1,060,366	5·39
Daltonganj	31,933	0·17	11,815	0·06
Giridih	659,101	3·47	713,598	3·58
Jainti	96,612	0·51	82,166	0·42
Jharia	9,936,299	52·27	10,346,015	52·63
Rajmahal Hills	2,801	0·01	2,635	0·01
Ramgarh	4,565	0·02	4,197	0·02
Rampur (Raigarh-Hingir)	68,618	0·36	50,796	0·26
Raniganj	5,203,214	27·37	5,557,424	28·28
Talcher	..	..	4,816	0·02
Burma—				
Lon-an (Kalaw)	172	..	2,003	0·01
Central India—				
Sohagpur	42,693	0·22	80,125	0·41
Umaria	118,538	0·62	95,825	0·49
Central Provinces—				
Ballarpur	132,680	0·70	112,362	0·57
Mohpani	84,906	0·45	87,387	0·44
Pench Valley	453,484	2·39	346,094	1·76
Shahpur	1,069	0·01	2,063	0·01
Yeotmal	3,687	0·02	168	..
Hyderabad—				
Sasti	38,522	0·20	29,204	0·20
Singareni	604,358	3·18	629,225	3·21
Total	**18,520,513**	**97·43**	**19,218,284**	**97·77**

The yield of the Makum field of Assam decreased practically to its figure for 1921; both Baluchistan fields shewed heavy decreases also. Rajputana produced less than half what it did the previous year, and the total from the Punjab shews a decrease.

TABLE 7.—*Output of the Tertiary Coalfields for the years 1922 and 1923.*

	1922.		1923.	
	Tons.	Per cent. of Indian total.	Tons.	Per cent. of Indian total.
Assam—				
Khasi and Jaintia Hills .	453	1·83	200	1·65
Makum . . .	291,747		270,343	
Naga Hills . . .	55,903		55,606	
Baluchistan—				
Kalat, Mach, Sor Range .	26,269	0·31	16,058	0·22
Khost	33,866		26,504	
Burma—				
Kamapying (Mergui) . .	..		163	0·00
Punjab—				
Jhelum	47,832	0·35	43,253	0·32
Mianwali	14,301		11,965	
Shahpur	5,047		8,283	
Rajputana—				
Bikaner	15,055	0·08	7,119	0·04
Total .	**490,473**	**2·57**	**439,494**	**2·23**

The export statistics shew an increase of nearly 59,500 tons, while the imports of coal and coke on the other hand fell to practically half what they totalled in 1922. Over two-fifths of the imports came from South Africa whose contribution increased by over 38,000 tons. Australia and "other countries" are the only other sources whose contributions shew an increase. From the United Kingdom imports fell from 718,500 to only 125,300 tons; from Japan India received a paltry 4,600 tons instead of 55,500 tons in the previous year.

TABLE 8.—*Exports of Indian Coal and Coke during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee = 1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
To—	Tons.	Rs.	£	Tons.	Rs.	£
Ceylon	76,466	10,24,893	68,326	119,616	20,19,641	134,643
Other Countries . . .	13	543	36	16,943	3,21,744	21,449
TOTAL .	76,479	10,25,436	68,362	136,559	23,41,385	156,092
Coke	632	36,997	2,466	16	575	38
Total of Coal and Coke .	**77,111**	*10,62,433*	*70,828*	**136,575**	*23,41,960*	*156,130*

TABLE 9.—*Imports of Coal, Coke and Patent Fuel during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee = 1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
From—	Tons.	Rs.	£	Tons.	Rs.	£
Australia and New Zealand	17,849	6,57,330	43,822	59,380	21,61,940	144,120
Japan	55,547	21,21,080	141,405	4,660	1,04,274	10,952
Portuguese East Africa	157,122	57,74,455	384,964	115,942	31,10,309	207,354
Union of South Africa .	231,548	72,07,760	480,517	269,777	69,31,688	462,113
United Kingdom .	718,487	2,78,80,912	1,858,727	125,260	44,98,522	299,901
Other Countries . . .	11,413	2,64,271	17,618	31,404	8,67,468	57,831
TOTAL .	1,191,966	4,39,05,808	2,927,054	606,423	1,77,34,201	1,182,280
Coke	28,673	14,52,654	96,843	18,495	9,18,802	61,253
Patent Fuel . .	..	..	..		..	..
Total of Coal, Coke, etc. .	**1,220,639**	*4,53,58,462*	*3,023,897*	**624,918**	*1,86,53,003*	*1,243,533*

The average number of persons employed daily in the coal-fields during the year remained practically the same as it was in 1922, while the average output per person employed shewed a slight improvement, rising from 94·6 tons in 1922 to 97·8 tons during the year under report; in 1919 this figure was 111·05 tons. The number of deaths by accident was unusually large, totalling 363, and corresponding to a death-rate of 1·81 per thousand persons employed; in 1922 the total figure was 243 corresponding to a rate of 1·21 per thousand.

TABLE 10.—*Average number of persons employed daily in the Indian Coalfields during 1922 and 1923.*

—	Number of persons employed daily. 1922.	1923.	Output per person employed.	Number of deaths by accident.	Death-rate per 1,000 persons employed.
Assam	3,636	3,901	83·6	13	3·3
Baluchistan	1,492	1,195	35·6	4	3·3
Bengal	44,893	41,251	104·4	73	1·6
Bihar and Orissa	119,790	123,554	106·9	211	1·7
Burma	65	197	10·9	..	..
Central India	2,595	2,762	63·7	1	0·4
Central Provinces	13,255	9,857	55·6	30	3·0
Hyderabad	13,402	13,558	48·6	28	2·1
Punjab	1,686	1,544	41·1	1	0·6
Rajputana	99	99	71·9	2	20·2
Total	**200,913**	**200,918**	..	363	..
Average	..	..	97·5	..	1·81

Copper.

Since 1919, following the commencement of smelting operations at the Rakha mines during the year 1918, the output of copper-ore in Singhbhum has been maintained with a fairly steady level till 1923. The decrease in the output of ore during that year was heavy, the amount totalling 6,500 tons only, valued at Rs. 65,500 (£4,367). This amount of the ore was obtained by the Cape Copper Company during the first quarter of the year, and from the 1st of April the works were closed down and pumping alone carried on. The amount of refined copper extracted from the ore amounted to 187·23 tons. The Rakha mines deposit is a low-grade sulphide ore containing two to four per cent. of copper, but a slightly improved grade of ore has recently been struck. Three other companies are prospecting in the Singhbhum belt, and one of these, the Cordoba Copper Company, has met with very promising ore-bodies in their Mosaboni mines. A zone of secondary enrichment, in which malachite and cuprite predominated, was pierced and an impoverished zone with practically no ore encountered beneath. The lode channel was, however, well defined, and beneath the impoverished zone chalcopyrite began to make its appearance in small lenses. At a vertical depth of 169 feet from the surface tunnels driven along the lode proved the presence of solid chalcopyrite, in some places 2 feet wide, over a considerable distance in length, and giving values varying between 10 per cent. and 25 per cent. of copper. Some very lucrative ore has been opened up by means of shafts sunk on this lode and there is every promise of an improvement in the outlook of copper production from this part of India.

The production of copper-ore in the State of Mysore during 1923 was *nil*.

Diamonds.

The output of diamonds from Central India amounted to 115·22 carats, valued at Rs. 46,495 (£3,100), as against 171·39 carats, valued at Rs. 91,618 (£6,110), in the preceding year.

Gold.

The total output of gold during the year under review fell to 422,306·56 oz. valued at £1,702,642. The increase shewn in the figures for 1922, which were 438,015·04 oz. valued at £1,857,577, was almost entirely a result of the treatment of accumulated cyanide slags; the amount of gold from these slags amounted to 3,172 oz. for that year, and during the year under review to over 1,000 oz.

TABLE 11.—*Quantity and value of Gold produced in India during the years 1922 and 1923.*

	1922.			1923.			
—	Quantity.	Value (Rupee—1*s*. 4*d*.)		Quantity.	Value (Rupee—1*s*. 4*d*.)		Labour.
	oz.	Rs.	£	oz.	Rs.	£	
Burma—							
Katha . .	12·01	815	51	23 16	1,672	111	42
Upper Chindwin	12	1,280	85	14·30	4,134	276	86
Madras—							
Anantapur .	8,388 (*a*)	6,08,673	40,578	1,519 (*a*)	1,01,016	6,734	275
Mysore . .	429,559·6(*b*)	2,72,50,073	1,816,072	(*c*) 419,667 61	2,53,69,141	1,691,276	20,604
				1,001·46(*d*)	60,690	4,046	
Punjab . .	40 8	2,638	176	48·8	2,860	191	62
United Provinces	2·63	175	12	1·9	125	8	12
Total .	**438,015·04**	*2,78,63,654*	*1,857,577*	**422,306·56**	*2,55,39,635*	1,702,642	21,081

(*a*) Fine gold.
(*b*) Contains 381,955·18 oz. fine gold including 3,172·24 oz. obtained from cyanide slags.
(*c*) Contains 381,058·03 oz. fine gold.
(*d*) Fine gold obtained from cyanide slags.

Iron.

The production of iron-ore increased by 28·6 per cent., *viz.*, from 625,274 tons in 1922 to 801,384 tons in 1923. The figure shown against Mayurbhanj in the following table represents the production by the Tata Iron and Steel Company Ltd.; although the raisings amounted to 507,225 tons. the total ore despatched from Mayurbhanj was 663,247 tons, the excess over production being taken from the balance of raisings in the year previous to 1922, which could not be despatched owing to the incompletion of railway sidings and consequently remained in stock. The production in Singhbhum is mostly that of the Bengal Iron Company, the Indian Iron and Steel Company being responsible for 9,909 tons from their mining at Gua. The Amda-Jamda railway extension to Gua has now been opened and the despatch of ore from that locality to the Indian Iron and Steel Company's blast furnaces at Hirapur commenced; previously these furnaces had been supplied with ore from Mayurbhanj State and the Central Provinces.

The Tata Iron and Steel Company produced 392,135 tons of pig iron, 151,097 tons of steel, including rails, and 3,506 tons of ferro-manganese, shewing a decided increase in each case over the previous year. The Bengal Iron Company produced 119,669 tons of pig iron and 41,849 tons of iron castings, also shewing substantial increases in the two cases. The Indian Iron and Steel Company commenced turning out pig iron, railway sleepers and railway "chairs" in November 1922; their production of pig iron during 1923 amounted to 77,980 tons.

TABLE 12.—*Quantity and value of Iron-ore produced in India during the years 1922 and 1923.*

—	1922			1923.		
	Quantity.	Value (Rupee = 1s 4d)		Quantity	Value (Rupee = 1s 4d)	
	Tons.	Rs	£	Tons.	Rs	£
Bihar and Orissa—						
Mayurbhanj	378,134	9 45,335	63 022	507,225	12,68,062	84,537
Sambalpur	798(*a*)	5,495	366	632(*a*)	1,427	205
Singhbhum	215,746	4,93,316	32,888	218,584	4 51,843	30,123
Burma—						
Mandalay	.	.	.	325	1,316(*a*)	88
Northern Shan States	27,680	1,10,720(*a*)	7,381	52,9[illegible]1	2,11,644(*a*)	14,110
Central Provinces	2,801	11,564	771	24,642	1,08,933	7,262
Other Provinces and States	25	(*b*)		71	(*b*)	.
Total	**625,274**	*15,66,130*	*101,128*	**804,384**	*20,46,226*	*136,415*

(*a*) Estimated. (*b*) Not available.

In the Central Provinces the number of indigenous furnaces in operation fell from 148 in 1922 to 119 in 1923, the decrease being mainly in the Bilaspur district. The output of iron ore in Burma is by the Burma Corporation, Limited, and is used as a flux in lead-smelting.

Jadeite.

The output of jadeite in Burma, which in 1922 was more than double that of the previous year, fell to below the 1921 figure during the year under review. In other words the output of 7,724·7 cwts., valued at Rs. 8,69,340(£57,956) for 1922, fell to 3,626·6 cwts. valued at Rs. 8,20,120 (£54,675) during 1923. It will be noticed that although the quantity of jadeite extracted decreased so markedly, there was very little corresponding fall in the total value: this is due to the higher quality of jadeite met with.

The export figures, from which a better idea of the extent of the jadeite industry is obtainable, for the year 1922-23 were 5,762 cwts. valued at Rs. 18,72,168 (£124,811) sinking to 3,088 cwts. valued at Rs. 8,37,052 (£55,803).

Lead.

There was a further increase of about 74,000 tons in the production of lead-ore at the Bawdwin mines, and the total amount of metal extracted increased from 39,214 tons, valued at Rs. 1,41,71,392 (£944,759) in 1922 to 46,060 tons valued at Rs. 1,68,18,111 (£1,121,207) in 1923. The quantity of silver extracted rose from 4,205,584 oz. valued at Rs. 1,00,39,362 (£669,291) to 4,843,939 oz. valued at Rs. 1,01,16,985 (£674,466). The value of the lead extracted increased from Rs. 361 (£24·1) per ton in 1922 to Rs. 365 (£24·4) per ton in the year under review, and that of silver decreased from Rs. 2-6-2 (38·2*d.*) to Rs. 2-1-5 (33·4*d.*) per oz.

A new feature has developed during the opening up of the Shan Lode to the north. High grade silver-copper ore has been developed aggregating 335,681 tons, averaging 11·1 per cent. copper and 23 oz. silver per ton. Tetrahedrite has been found on No. 5 Level of the Shan Lode, assaying silver, 579 oz., lead, trace, zinc, 2·9 per cent., copper 26·5 per cent.

TABLE 13.—*Production of Lead and Silver Ore during 1922 and 1923.*

	1922					1923.				
	QUANTITY.	VALUE (RUPEE=1*s* 4*d*)				QUANTITY	VALUE (RUPEE=1*s* 4*d*)			
	Lead-ore.	Lead-ore and Lead		Silver.		Lead ore.	Lead-ore and lead.		Silver.	
	Tons	Rs.	£	Rs	£	Tons	Rs.	£	Rs.	£
Burma—										
Northern Shan States	172,017	1,41,71,392(*a*)	944,759 5	1,00,39 362(*b*)	669,291	245,892	1,68,18,111(*c*)	1,121,207	1,01,16,985(*d*)	674,466
Southern Shan States	48 8	5,625	375			33	4,000	267	.	
Central Provinces—										
Drug . .	1	36	2 4						.	.
Total	**172,066 8**	*1,41,77,053*	*945 136 9*	*1,00 39 362*	*669 291*	**245,925**	*1,68,22,111*	*1,121,474*	*1,01,16 985*	*674,466*

(*a*) Value of 39 214 tons of lead extracted
(*b*) Value of 4 205 584 oz of silver extracted
(*c*) Value of 46 060 tons of lead extracted
(*d*) Value of 4 843 939 oz of silver extracted

Magnesite.

The revival of the magnesite industry in 1921 has maintained itself ever since. The figures for 1922, 19,273 tons valued at Rs. 2,40,692 (£16,046), have been exceeded slightly by those for 1923 which are 19,436 tons valued at Rs. 2,34,332 (£15,622).

TABLE 14.—*Quantity and value of Magnesite produced in India during 1922 and 1923.*

	1922.			1923.		
	Quantity.	Value (Rupee = 1*s.* 4*d.*)		Quantity.	Value (Rupee = 1*s.* 4*d.*)	
	Tons	Rs.	£	Tons	Rs.	£
Madras—						
Salem	18,417	2,21,004	14,734	19,336	2,32,032	15,469
Mysore	856	19,688	1,312	100	2,300	153
Total	19,273	*2,40,692*	*16,046*	19,436	*2,34,332*	*15,622*

Manganese.

The output of manganese ore in India rose from 474,401 tons, valued at £915,428 f.o.b. at Indian ports, in the previous year, to 695,055 tons, valued at £2,215,984 f.o.b. Indian ports during 1923. The localities chiefly responsible for this increase were most of the areas in the Central Provinces, Vizagapatam and Sandur State in Madras, Shimoga in Mysore and Gangpur in Bihar and Orissa; each of the two fields of Bombay shewed an appreciable decrease. As in many other mineral industries that of manganese is apt to fluctuate with agricultural conditions. A good harvest will absorb the attention of labour and thus adversely affect the output of a mineral deposit; conversely mineral industries usually reap the benefit of a bad monsoon.

It will be noticed from tables 15 and 16, that the excess of exports over production which amounted to about 400,000 tons in 1922, has continued during 1923 to the extent of 155,000 tons, and is evidently a result of previous accumulation of stocks. The total exports from British Indian ports (table 17) increased by about 1,000 tons. The enormous increase of over 150,000 tons to the United Kingdom during 1922 has been repeated during 1923 to the extent of some 83,400 tons. France, America, Italy and Japan all took considerably more than they did in 1922, while Belgium, Holland and Germany absorbed less. In the case of Belgium, which transmits a portion of her imports to Germany, the decrease amounted to no less than 141,600 tons.

TABLE 15.—*Quantity and value of Manganese-ore produced in India during 1922 and 1923.*

	1922.		1923.	
	Quantity.	Value f. o. b. at Indian ports.	Quantity.	Value f. o. b at Indian ports.
	Tons.	£	Tons.	£
Bihar and Orissa—				
Gangpur . .	16,372	32,062	20,439	67,619
Keonjhar .		..	1,968	5,452
Singhbhum .	..	..	46	152
Bombay—				
Chhota Udaipur .	17,193	31,664	12,553	39,333
Panch Mahals .	39,703	75,436	35,354	113,869
Central Provinces—				
Balaghat .	169,182	331,315	224,746	743,535
Bhandara	41,143	80,572	79,949	264,498
Chhindwara	33,473	65,551	30,066	99,468
Jubbulpore	.	..	55	182
Nagpur .	132,152	258,798	196,493	650,064
Madras—				
Bellary .	..	..	2,429	6,255
Sandur State	1,470	1,458	37,318	75,413
Vizagapatam	7,845	9,349	22,524	52,650
*Mysore—**				
Chitaldrug	1,725	3,177	1,225	3,838
Mysore	..	..	1,200	3,760
Shimoga .	14,018	25,816	28,377	88,915
Tumkur .	125	230	313	981
Total .	**474,401**	*915,128*	**695,055**	2,215,984

* The value figures are subject to revision.

TABLE 16.—*Exports of Manganese-ore during 1922 and 1923 according to Ports of Shipment.*

	1922.	1923.
	Tons.	Tons.
Bombay	389,442	386,255
Calcutta	371,708	375,340
Vizagapatam	13,710	14,275
Mormugao (Portuguese port)	87,917	74,454
Total	**862,777**	**850,324**

TABLE 17.—*Exports of Manganese-ore from British Indian ports during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value. (Rupee = 1*s.* 4*d.*)		Quantity.	Value (Rupee = 1*s.* 4*d.*)	
	Tons.	Rs	£	Tons.	Rs.	£
To—						
United Kingdom	247,517	50,80,464	338,698	330,948	67,49,031	449,935
Germany	8,017	1,76,595	11,773	7,250	1,48,125	9,875
Netherlands	30,100	5,60,250	37,350	17,200	3,08,350	20,557
Belgium	209,656	70,66,054	471,070	158,013	38,67,943	257,863
France	150,665	33,79,202	225,280	173,057	35,91,847	239,457
Italy	11,700	2,95,650	19,710	19,862	5,88,397	39,226
Japan	1,351	36,714	2,448	5,657	1,39,038	9,269
United States of America	24,924	6,81,383	45,425	63,883	21,38,001	142,533
Total	**774,860**	*1,72,76,312*	*1,151,754*	**775,870**	*1,75,30,732*	*1,168,715*

Mica.

There was an increase of about 1,980 cwts. in the declared output of mica in 1923 above that of the previous year. As has been frequently pointed out, the output figures are incomplete, and a better idea of the size of the industry is obtained from the export figures. The exports of mica during 1923 amounted, in fact, to more than double the declared output, equalling 83,296 cwts., valued at Rs. 80,76,522 (£538,435); this figure is not far short of double that for the previous year 1922, which was 43,145 cwts., valued at Rs. 57,85,245 (£385,683). It will be noticed, however, that the average price of the mica fell from Rs. 134 (£8·9) to Rs 97 (£6·5) per cwt.

TABLE 18.—*Quantity and value of the production of Mica in India recorded during 1922 and 1923.*

	1922			1923.		
	Quantity	Value (Rupee = 1s 4d)		Quantity	Value (Rupee = 1s 4d)	
	Cwts	Rs	£	Cwts	Rs	£
Bihar and Orissa						
Gaya	[illegible]	1,40,805	9,387	2,919	1,10,785	7,386
Hazaribagh	13,120·8	9,08,680	60,579	30,819	10,65,166	71,011
Monghyr	5	90	6	15	[illegible]	15
Central Provinces	100	(a)		..	..	..
Madras						
Nellore	1,216·2	80,951	[illegible]	8,671	3,14,703	20,980
Nilgiris	11	6,227	415	113	23,912	1,594
Mysore—						
Hassan	15·2	(a)		16	1,209	81
Mysore	190·5	(a)	..	(b)32·7	548	37
Rajputana—						
Ajmer Merwara	[illegible]	[illegible]	2,799	[illegible]	52,880	3,525
Shahpura	98	15,658	1,044	640·2	18,217	1,214
Total	31,878·1	12,02,701	80,180	33,855·2	15,87,915	1,05,861

(a) Not available.
(b) Excludes 370·7 cwts. of raw mica.

Monazite.

There was a recovery in the output of monazite in Travancore, which rose from 125 tons, valued at £1,871 in 1922 to 216·3 tons, valued at £3,697, in the year under review, but the amount is still very far short of the 1,260 tons obtained during 1921 and valued at nearly £31,000.

Petroleum.

The statistics of petroleum shew that it is becoming more and more difficult to maintain the output of India (including Burma) at the high level it reached in 1919 and 1921, which amounted to well over 305½ million gallons. During the year under consideration the total production amounted to nearly 294¼ million gallons against 298½ million gallons in 1922; for this decrease the two largest fields of Burma, Yenangyaung and Singu were mostly responsible.

The Yenangyat field is rapidly dying, and its yield is now less than that from Thayetmyo. As in the previous year the Singu and Yenangyaung oil-fields again shew a decided decrease, the outputs falling by $4\frac{3}{8}$ million gallons and 4½ million gallons respectively. Thayetmyo and Badarpur contributed, to much the same extent in each case, to the general deficit; the latter field is a disappointment and shews no promise of making any substantial contribution to India's output of petroleum. Against these declines are to be recorded an increase in the Digboi field of over 2 million gallons and a gratifying increase of nearly 4½ million gallons in the Punjab. Minbu and the Upper Chindwin more or less maintained their level.

The utilization of the shallow oil-sands of the Yenangyaung field which were shut off during the competitive rush for the richer deep sands, continues; several remunerative wells are now being worked at depths a little above or below 400 feet. The electrification of this field has extended itself and more than 700 wells are now being either pumped or drilled, by electricity. The Indo-Burma Oilfields Ltd. have now ceased operations in the Yenangyaung field.

During the year active prospecting was continued in the Punjab, Assam and Burma, by a variety of oil interests.

In the Punjab the oil industry entered on a new phase with the completion at Rawalpindi, and the opening in February 1922, of the refinery erected by the Attock Oil Company to deal with the production of the Khaur oilfield in the Attock district. The refinery has a daily capacity of 65,000 gallons of crude oil, but the average throughput has not yet reached the maximum. The test wells in the Dhulian and Gabbir areas reached the depths of 2,800 feet and 1,760 feet respectively without striking oil in remunerative quantity; both wells have been abandoned but a fresh test at Dhulian has already been started.

TABLE 19.—*Quantity and value of Petroleum produced in India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
	Gals.	Rs.	£	Gals.	Rs.	£
Assam—						
Badarpur . .	4,038,731	(*a*)6,66,794	44,453	3,555,377	4,01,912	26,794
Digboi . .	5,343,910	(*b*) 9,12,918	60,861	7,448,719	12,71,935	84,796
Burma—						
Akyab . .	8,886	2,563	171	8,628	2,573	172
Kyaukpyu . .	16,211	17,529	1,169	16,721	16,714	1,114
Minbu . .	3,940,416	12,31,380	82,092	3,915,140	12,23,481	81,565
Singu .	92,107,998	3,45,73,653	2,304,910	87,476,474	3,28,03,678	2,186,912
Thayetmyo. .	2,319,835	7,24,948	48,330	1,818,584	4,54,646	30,310
Upper Chindwin .	1,210,914	90,818	6,055	1,311,644	98,374	6,558
Yenangyat .	2,413,416	7,54,192	50,279	1,700,035	4,42,717	29,514
Yenangyaung .	179,741,493	6,72,22,038	4,481,469	175,158,721	6,54,51,455	4,363,430
Punjab—						
Attock . .	7,362,315	18,40,579	122,705	11,804,560	29,51,140	196,743
Mianwali . .	..	..	..	450	112	7
Total .	**298,504,125**	*10,80,37,412*	*7,202,494*	**294,215,053**	*10,51,18,737*	*7,007,915*

(*a*) Revised.
(*b*) Estimated at Rs. 0-2-8·8 per gallon.

The increase in the imports of kerosene oil reported during the previous year, continued to almost the same extent during the year under review, amounting to over 10 million gallons, the increase being shared by all countries concerned.

During 1923 the export of paraffin wax again decreased by over 3,000 tons.

TABLE 20.—*Imports of Kerosene Oil during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1*s.* 4*d.*).		Quantity.	Value (Rupee=1*s.* 4*d.*).	
	Gals.	Rs.	£	Gals.	Rs.	£
From—						
Borneo . .	7,245,454	36,75,965	245,064	10,045,993	52,69,607	351,307
Straits Settlements (including Labuan)	956,350	4,33,348	28,890	1,807,059	10,52,739	70,183
Sumatra .	..	..	..	1,678,770	8,65,615	57,708
United States of America.	43,088,869	3,22,16,428	2,147,762	45,477,974	3,14,97,214	2,099,814
Other Countries.	2,560,139	17,15,763	114,384	5,053,841	29,98,573	199,905
Total .	**53,850,812**	*3,80,11,504*	*2,536,100*	**64,063,637**	*4,16,83,748*	*2,778,917*

TABLE 21.—*Exports of Paraffin Wax from India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee=1*s.* 4*d.*).		Quantity	Value (Rupee=1*s.* 4*d.*)	
	Tons.	Rs.	£	Tons.	Rs	£
To—						
Australia and New Zealand.	2,143	8,72,960	58,197	1,287	5,85,671	39,045
Belgium .	660	3,00,300	20,020	1,405	6,39,275	42,618
China . .	4,978	22,25,658	148,377	6,254	28,29,744	188,650
Italy . .	1,300	5,91,500	39,433	120	54,600	3,640
Japan . .	8,319	37,62,285	250,819	6,627	30,35,200	202,347
United Kingdom.	3,984	18,24,013	121,601	2,779	12,68,960	84,597
Union of South Africa.	2,264	10,30,574	68,705	1,745	7,93,100	52,873
United States of America.	1,250	5,68,750	37,917	1,104	5,02,447	33,497
Other Countries.	2,738	12,33,037	82,202	3,243	14,35,263	95,684
Total .	**27,636**	*1,24,09,077*	*827,271*	**24,564**	*1,11,44,260*	*742,951*

Ruby, Sapphire and Spinel.

There was a decrease in the output of the Mogok ruby mines in 1923, bringing the figure below what it was in 1921. The total weight, however, has little meaning in the case of precious stones, and in spite of the marked decrease in this figure, for which sapphires were mostly responsible, the value actually increased, this is accounted for by the greater value of the rubies and the spinels.

TABLE 22.—*Quantity and value of Ruby, Sapphire and Spinel produced in India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee 1s. 4d.).		Quantity.	Value (Rupee 1s. 4d.).	
	Carats.	Rs.	£	Carats.	Rs.	£
Burma . .	93,078 (Rubies)	6,45,304	43,020	92,592 (Rubies)	6,63,064	44,204
	102,462 (Sapphires)	76,045	5,070	65,692 (Sapphires)	59,207	3,947
	35,620 (Spinels)	5,963	397	28,726 (Spinels)	7,917	528
Total .	**231,160**	*7,27,312*	*48,487*	**187,010**	*7,30,188*	*48,679*

Salt.

There was again an increase in the production of salt during 1923 over that of the preceding year, amounting to over 127.000 tons, for which Bombay and Sind were more than responsible. The increase in Madras of some 20,000 tons was balanced by a deficit to the same approximate extent in Northern India. Aden shewed a fall of nearly 35,000 tons.

Against the above increase there was a severe deficit in the output of rock-salt amounting to some 87.600 tons. The imports of salt remained very steady, shewing an increase of scarcely more than 1,600 tons.

TABLE 23.—*Quantity and value of Salt produced in India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee = 1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
Aden	204,033	11,87,443	79,163	169,282	10,04,852	66,990
Bengal	3	106	7	..	..	..
Bombay and Sind.	450,558	27,18,435 (a)	181,229	613,150	34,41,843	229,456
Burma	33,535	13,21,390	88,093	33,622	[6,99,000	46,600
Central India	9·7	528	35	9·3	504	34
Gwalior *	210	10,007	667	22	1,061	71
Kashmir	..	..	..	0·6	100	6
Madras	465,929	29,43,066	196,204	485,569	30,70,226	204,682
Northern India	499,386	29,81,926	198,795	479,295	30,13,046	200,870
Rajputana (Jaisalmer State).	234·5	11,596	773	206	10,103	673
Total	**1,653,898·2**	*1,11,74,497*	*744,966*	**1,781,155·9**	*1,12,40,735*	*749,382*

* Figures relate to the official years 1922-23 and 1923-24.
(a) Revised.

TABLE 24.—*Quantity and value of Rock-salt produced in India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee = 1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
Salt Range	183,533	9,36,785	62,452	100,932	5,14,755	34,317
Kohat	18,904	56,444	3,763	14,640	46,744	3,116
Mandi	*4,875	87,095	5,806	4,101	83,080	5,539
Total	**207,312**	*10,80,324*	*72,021*	**119,673**	*6,44,579*	*42,972*

TABLE 25.—*Quantity and value of Salt imported into India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee = 1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
From—						
United Kingdom.	79,169	27,66,846	184,456	110,958	29,79,674	198,645
Germany .	49,301	15,33,763	102,251	35,720	9,86,386	65,759
Spain . .	55,165	15,91,597	106,107	45,579	13,40,659	89,377
Aden and Dependencies.	165,777	50,11,039	334,069	165,499	38,82,266	258,818
Egypt . .	106,647	31,35,660	209,044	76,143	18,47,153	123,143
Italian East Africa.	50,980	15,75,359	105,024	74,826	22,60,240	150,683
Other countries	25	2,794	186	15	2,325	155
Total .	**507,073**	*1,56,17,058*	*1,041,137*	**508,740**	*1,32,98,703*	*886,580*

Saltpetre.

There was a further decrease of over 3,000 tons in the total output of saltpetre. Bihar and the Punjab were mainly responsible for this decrease, where the outputs fell by 21 per cent. and 39 per cent. respectively. The total Indian production amounted to 8.555·4[1] tons valued at Rs. 22,46,355 (£149,757) against 11,672·9 tons valued at Rs. 35,22,995 (£234,866) in 1922. Exports also decreased from 11,000 tons in 1922 to 8,000 tons in the year under consideration, the decreases being shared by all the recipient countries except Mauritius and its Dependencies.

[1] It has been discovered that Calcutta and Madras have been producing saltpetre for some years past. The amount produced in Calcutta in 1923 was 22·6 tons, and in Madras 138·1 tons.

TABLE 26.—*Quantity and value of Saltpetre produced in India during the years 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee = 1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
	Tons.	Rs	£	Tons.	Rs.	£
Bihar (refined) .	2,009·1	5,05,494	33,700	1,622·9	3,86,243	25,749
Do. (*Kuthea*)	1,770	2,61,423	17,428	1,359·8	1,98,978	13,265
Central India .	15·8	3,780	252	18	4,030	269
Punjab . .	5,038·6	18,93,015	126,201	3,056·5	9,76,860	65,124
Rajputana .	182	46,487	3,099	...	...	...
United Provinces	2,657·4	8,12,796	54,186	2,498·2	6,80,244	45,350
Total .	**11,672·9**	*35,22,995*	*231,866*	**8,555·4**	*22,46,355*	*149,757*

TABLE 27.—*Distribution of Saltpetre exported during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee = 1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
To—						
Ceylon . .	62,003	7,49,349	49,957	55,017	7,00,637	46,709
Hongkong .	51,591	12,60,460	84,031	25,949	5,68,629	37,909
Mauritius and Dependencies	26,225	4,59,461	30,631	47,109	8,35,998	55,733
Straits Settlements including Labuan.	8,132	2,09,019	13,934	5,216	1,17,337	7,823
United Kingdom.	50,898	7,42,310	49,487	17,313	2,92,309	19,487
United States of America.	4,362	61,438	4,096	...	...	...
Other countries	17,667	2,95,013	19,667	10,753	1,91,672	12,778
Total .	**220,878**	*37,77,050*	*251,803*	**161,357**	*27,06,582*	*180,439*

Silver.

There was a further increase in the output of silver from Bawdwin, amounting to some 638,350 oz. The production from the Kolar gold mines on the other hand amounted to half that of the previous year. The yield from the Anantapur gold mines fell from 554 oz. in 1922 to only 103 oz. in 1923. The total Indian production was 4,863,066 oz. valued at Rs. 1,01,58,102 (£677,207).

TABLE 28. *Quantity and value of Silver produced in India during 1922 and 1923.*

	1922.			1923.		
	Quantity.	Value (Rupee 1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
	Ozs.	Rs.	£	Ozs.	Rs.	£
Burma— Northern Shan States.	4,205,584	1,00,39,362	669,291	4,843,939	1,01,16,985	674,466
Madras— Anantapur .	554	1,231	82	103	202	13
Mysore— Kolar . .	38,166	87,911	5,861	19,024	40,915	2,728
Total .	**4,244,304**	*1,01,28,504*	*675,234*	**4,863,066**	*1,01,58,102*	*677,207*

Tin Ore.

There was again a small increase in the production of tin-ore amounting to 121 tons. The total production of 1,996 tons was derived from Burma, Tavoy contributing 73·8 per cent., and Mergu 25·9 per cent. No block tin seems to have been produced by Mergui. Imports of unwrought tin increased considerably from 34,459 cwts. in 1922 to 48,342 cwts. in 1923; 90·7 per cent. of these imports came from the Straits Settlements.

TABLE 29.—*Quantity and value of Tin and Tin-ore for the years 1922 and 1923.*

	1922						1923					
	BLOCK TIN.			TIN-ORE			BLOCK TIN			TIN-ORE		
	Quantity.	Value (Rupee=1s 4d).		Quantity	Value (Rupee=1s 4d).		Quantity	Value (Rupee=1s 4d).		Quantity	Value (Rupee=1s 4d)	
	Tons.	Rs	£	Tons.	Rs	£	Tons.	Rs	£	Tons.	Rs.	£
Burma—												
Amherst .	..	..	..	11 8	16 339	1,089	..	..	..	3·2	2,002	133
Mergui .	217 8	5,33,395	35,560	407 6	5 87,184	39,146	..	..	..	516·8	8,07,923	53,862
Tavoy .	..	..	..	1,445	16,83,723	112,249	..	..	..	1,473	19,70,786	131,386
Thaton .	..	..	..	10·3	13,790	919	..	.	..	3	3,900	260
Total .	**217·8**	*5,33,395*	*35,560*	**1,874·7**	*23,01,041*	*153,403*	..	..	..	**1996·0**	*27,84,611*	*185,641*

TABLE 30.—*Imports of unwrought Tin (block, ingots, slabs) into India during 1922 and 1923.*

—	1922.			1923.		
	Quantity.	Value (Rupee = 1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
From—						
United Kingdom.	3,242	3,90,077	26,005·1	3,755	5,09,977	33,998
Straits Settlements (including Labuan).	30,311	37,76,181	251,745·4	43,835	59,74,758	398,317
Other countries	906	1,09,461	7,297·4	752	1,06,887	7,126
Total	34,459	*42,75,719*	*285,047·9*	48,342	*65,91,622*	*439,441*

Tungsten.

The production of wolfram decreased slightly from 943 tons valued at Rs. 3,75,532 (£25,035) during the previous year, to 872 tons valued at Rs. 4,79,693 (£31,979) in 1923. The decrease in output was, however, accompanied by a considerable increase in total value, amounting to £6,944. Practically the whole of the output was derived from the Tavoy district. Recent experiments have found a use for tungsten carbide as a substitute for the "bort" used in the crowns of core-drills. The carbide is said to have a hardness very little inferior to "bort," and to be cheaper. As the price of "bort" is between £10 and £12 a carat, the substitution of tungsten carbide may add a much needed impetus to the wolfram-mining industry.

TABLE 31. *Quantity and value of Tungsten-ore produced in India during 1922 and 1923.*

	1922.			1923.		
	Quantity.	Value (Rupee = 1s. 4d.)		Quantity.	Value (Rupee = 1s. 4d.)	
	Tons.	Rs.	£	Tons.	Rs.	£
Burma—						
Mergui . .	4·75	4,274	285	0·2	52	3
Tavoy . .	938	3,71,048	24,736	871·8	4,79,641	31,976
Thaton . .	0·25	210	14	..	.	..
Total .	**943·00**	*3,75,532*	*25,035*	**872·0**	*4,79,693*	*31,979*

Zinc.

2,062 tons of zinc ore were exported during the year 1923 against 18,061 tons in the preceding year. The ore is found in association with galena in the Bawdwin mines leased by the Burma Corporation, Limited.

III.—MINERALS OF GROUP II.

Alum.

The production of alum in the Mianwali district of the Punjab decreased by 48 per cent. The output amounted to 3,456 cwts. valued at Rs. 64,472 (£4,298) in 1923 as against 6,632 cwts. valued at Rs. 99,760 (£6,651) in 1922.

Amber.

The production of amber in Burma rose from 3·6 cwts. valued at Rs. 1,960 (£131) in 1922 to 47·9 cwts. valued at Rs. 13,720 (£915) in the year under review.

Apatite.

An output of 1,082 tons of apatite was reported from the apatite magnetite deposits of Singhbhum; the value of the production was Rs. 10,820 (£721). There was also a production of 3,680 tons of "phosphate" valued at Rs. 70,000 (£4,667) from the Nandup area in Singhbhum, against 1,340 tons valued at Rs. 17,000 (£1,133) in 1922.

Asbestos.

The production of asbestos amounted to 247 tons valued at Rs. 9,880 (£659) in 1923 as against 212 tons valued at Rs. 10,520 (£701) in the preceding year. The whole output came from the Hassan district in Mysore State. There was no production from the Central Provinces.

Barytes.

Of the total production of 2,570 tons of barytes valued at Rs. 42,749 (£2,850), 1,603 tons valued at Rs. 22,749 (£1,517) were reported from the Karnul district of the Madras Presidency, and the balance, 967 tons valued at Rs. 20,000 (£1,333), from the Alwar State, Rajputana. The total output in 1922 amounted to 2,392·2 tons valued at Rs 18,000 (£3,200).

Bauxite.

An output of 5,768 tons of bauxite valued at Rs. 51,065 (£3,604) was reported from Kaira in the Bombay Presidency. The Katni Cement and Industrial Company, Limited, extracted 779 tons of bauxite valued at Rs. 1,168 (£78) from the mines in the Jubbulpore district, Central Provinces. There was no production of bauxite in the Savantvadi State during the year 1923.

Building materials and Road-metal.

The total estimated value of building stone and road-metal produced in the year under consideration was Rs. 76,86,138 (£512,409), (see Table 32). Certain returns supplied in cubic feet have been converted into tons on the basis of certain assumed relations between volume and weight.

TABLE 32.—*Production of Building Materials and Road Metal in India during 1923.*

	Granite and Gneiss.		Laterite.		Lime.		Limestone and Kankar.		Marble.		Sandstone.		Slate.		Trap.		Miscellaneous.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£	Tons.	£	Tons	£	Tons	£	Tons	£	Tons.	£	Tons.	£	Tons.	£
Assam	2,648	429	3,836	606	..	..	121,983	18,363	..	..	1,967	231	..	..	..	..	81,475	8,460
Baluchistan	..	..	..	..	..	..	2	(a)	..	..	..	..	..	..	..	..	..	..
Bihar and Orissa	1,284	14	5,143	84	40,461	17,516	432,048	61,744	..	..	16,357	1,697	4,325	2,968	10,147	1,107	203,198	16,766
Bombay	..	..	..	..	..	..		..	..	..	..	..	..	..	..	..	..	..
Burma	82,296	13,659	158,376	14,469	..	..	234,770	26,793	..	.	77,046	5,074	..	..	..	..	287,900	17,249
Central India	..	..	.	.	14,789	15,171	118,987	4,537	.	.	.	..	..	..	..	..	18	(a)
Central Provinces	..	..	..	.	..	..	259,986	35,429	..	.	..	..	..	..	..	..	..	..
Gwalior	..	..	..	..	..	..	1,971	443	..	..	11,637	4,616	..	..	..	..	..	..
Kashmir	..	..	..	..	..	..	..	.	..	.	..	..	..	..	..	..	..	..
Madras	5,992	59	80,414	3.797	.	..	20,730	4,602	..	..	..	..	113	15	..	..	117.525	7,326
Mysore	..	..	3 548	512	7,824	1,689	9,915	2,229	..	..	5	1	..	..	..	..	52,383	2,939
N. W. F. Province	..	..	..	..	..	..	.	..	..	..	..	..	..	..	..	..	5,155	325
Punjab	..	..	..	..	..	..	33,248	1,783	..	.	..	..	7,919	9,605	..	..	67,438	3,285
Rajputana	..	..	..	..	..	..	171,380	19,391	4,972	10,043	178,016	73,618	150	133	..	..	80,916	7,000
United Provinces	..	..	..		..	..	104,999	9,556	..	.	..	..	784	296	..	..	1,433,662	86,795
TOTAL	92,220	*14,161*	251,317	*19,468*	63,074	*34,376*	1,510,919	*184,870*	4,972	*10,043*	285,028	*85,237*	13,291	*13,012*	10,147	*1,107*	2,329,670	*150,135*

(The value in sterling pounds has been calculated on the basis of Rupee 1 = 1*s*. 4*d*.)
(*a*) Not available

Clay.

The recorded production of clay rose from 102,755 tons, valued at Rs. 2,53,502 (£16,900) in 1922 to 148,112 tons valued at Rs. 3,20,333 (£21,356) in 1923.

TABLE 33.—*Production of Clays in India during 1923.*

—	Quantity.	Value (Rupee=1s. 4d.).	
	Tons.	Rs.	£
Bengal	38,396	62,952	4,197
Bihar and Orissa	7,953	1,28,904	8,594
Burma	34,871	40,767	2,718
Central India	386	670	45
Central Provinces	37,279	21,360	1,424
Delhi	3,676	3,908	261
Gwalior	536	7,326	488
Madras	110	200	13
Mysore	23,985	52,201	3,480
Rajputana	920	2,045	136
Total	**148,112**	*3,20,333*	*21,356*

Fuller's Earth.

There was a further and larger rise in the total production of Fuller's Earth, amounting to 27,696 tons valued at Rs. 57,168 (£3,811), against 13,550 tons valued at Rs. 36,764 (£2,451) in 1922.

TABLE 34.—*Production of Fuller's Earth during 1922 and 1923.*

	1922.			1923		
	Quantity.	Value (Rupee=1s 4d)		Quantity	Value (Rupee=1s 4d.).	
	Tons.	Rs.	£	Tons	Rs.	£
Central Provinces—						
Jubbulpore	152	748	50	80	393	26
Rajputana—						
Bikanir State	1,387	7,356	490	110	585	39
Jaisalmer State	11	100	7	6	90	6
Jodhpur State	12,000	28,560	1,904	27,500	56,100	3,740
Total	**13,550**	*36,764*	*2,451*	**27,696**	*57,168*	*3,811*

Gypsum.

The production of gypsum fell from 12,329·5 tons valued at Rs. 19,725 (£1,315) in 1922 to 10,280 tons valued at Rs. 17,351 (£1,156) in the year under review. The mineral hitherto reported from the Bikanir State in Rajputana as " sweet lime ", the vernacular name for gypsum, has been found on examination to be deposited limestone, slightly tufaceous, with a little sulphate.

TABLE 35.—*Production of Gypsum during 1922 and 1923.*

	1922.			1923.		
	Quantity.	Value (Rupee 1s. 4d.).		Quantity.	Value (Rupee 1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
Kashmir . .	73·5	500	33	(a)	304(b)	20
Punjab—						
Jhelum .	7,801	6,825	455	5,197	4,547	303
Rajputana—						
Jaisalmer .	55	400	27	83	500	33
Marwar .	4,400	12,000	800	5,000	12,000	800
Total .	**12,329·5**	*19,725*	*1,315*	**10,280**	*17,351*	*1,156*

(*a*) The output amounted to 1,880 cu. ft. The weight in tons is not available.
(*b*) Represents royalty paid to the State.

Hyalite.

An output of 12·5 cwts. of hyalite, a colourless variety of opal, valued at Rs. 5,282 (£352) was reported from Katha in Burma.

Ilmenite.

The output of ilmenite rose from 400 tons valued at £1,200 in 1922 to 700 tons valued at £2,100 in 1923.

Ochre.

The total production of ochre in 1923 amounted to 8,705·6 tons valued at Rs. 66,922 (£4,461), against 6,701·4 tons valued at Rs. 57,086 (£3,805) in the preceding year.

TABLE 36.—*Production of Ochre during the years 1922 and 1923.*

	1922.			1923.		
	Quantity.	Value (Rupee = 1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar and Orissa	400	10,400	693	441	11,078	738
Central India .	4,769·9	35,730	2,382	4,483·6	35,609	2,374
Central Provinces	697	5,139	343	2,449	8,195	546
Gwalior . .	832	5,720	381	895	6,265*	418
Kashmir . .	0·5	7	..	..	..	..
Madras . .	..	..	..	135	5,400	360
Rajputana .	2	90	6	2	75	5
Total .	**6,701·4**	*57,086*	*3,805*	**8,705·6**	*66,922*	*4,461*

* Estimated.

Soda.

There was a decrease in the production of soda in the Ladak tahsil, Kashmir, from 28 tons, valued at Rs. 1,021 (£68) in 1922 to about 7 tons, valued at Rs. 249 (£17) in the year under review. Salt consisting for the greater part of sodium carbonate, sodium bicarbonate and sodium chloride is obtained by evaporation from the waters of the Lonar Lake in the Buldana district of the Central Provinces. It is known under the general name of *trona* or *urao* for which there is no suitable equivalent in English. Its three chief varieties are *Dalla khar, Papadi* and *Bhooski*, according to the proportion of neutral carbonate; the first contains sodium chloride sometimes to the extent of 50 per cent. The total amount of *trona* or *urao* extracted in 1923 was 600 tons valued at Rs. 23,750 (£1,583).

Steatite.

There was a considerable rise in the production of steatite from 906 tons valued at Rs. 36,489 (£2,432) in 1922 to 2,257 tons valued at Rs. 49,353 (£3,290) in the year under consideration.

TABLE 37.—*Quantity and value of Steatite produced in India during the years 1922 and 1923.*

	1922.			1923.		
	Quantity.	Value (Rupee = 1*s*. 4*d*.).		Quantity.	Value (Rupee = 1*s*. 4*d*.).	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar and Orissa—						
Mayurbhanj .	71	6,900	460	65	6,000	400
Singhbhum .	0·55	31	2	76·8	4,424	295
Burma—						
Pakokku Hill-Tracts.	3·05	585	39	3·1	600	40
Central India—						
Bijawar . .	0·6	94	6	0·4	64	4
Central Provinces.						
Jubbulpore .	89·8	1,852	123	999	9,249	617
Madras—						
Nellore . .	70·4	3,969	265	77	4,417	294
Salem . .	542·6	14,298	953	890·2	20,947	1,396
Mysore . .	93·5	935	62	108	960	64
United Provinces						
Hamirpur .	27	7,425	495	34	2,500	167
Jhansi . .	8	400	27	4	192	13
Total .	**906·50**	*36,489*	*2,432*	**2,257·5**	*49,353*	*3,290*

Zircon.

The production of zircon in the Travancore State fell from 160 tons valued at £1,280 in 1922 to 145 tons valued at £1,160 in 1923.

IV.—MINERAL CONCESSIONS GRANTED.

TABLE 38.—*Statement of Mineral Concessions granted during 1923.*

ASSAM.

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Cachar .	(1) The Burma Oil Co., Ltd.	Mineral Oil	P. L.	360	4th January 1923	year.
Do. .	(2) Whitehall Petroleum Corporation, Ltd.	Crude petroleum and its associated hydro-carbons.	P. L.	2,585·60	25th March 1923.	Do.
Garo hills	(3) Messrs. Gillander Arbuthnot & Co. on behalf of the Garo Hills Mining Syndicate.	Coal .	P. L.	6,720	9th May 1922	Do.
	(4-9) Do. . .	Do.	P. L. (renewal).	6,720 (consisting of six blocks).	Do	Do.
Lakhimpur	(10) The Assam Oil Co. .	Oil	M. L.	160	6th April 1923.	5 years.
Do	(11) Do.	Do.	P. L.	4,160	20th April 1923.	1 year.
Do	(12) Do.	Do.	P. L.	3,968	12th May 1923.	Do.
Do	(13) Do. .	Do.	P. L.	4,180	7th April 1923.	Do.

BENGAL.

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chittagong Hill Tracts.	(14) Messrs. Bulloch Bros.	Mineral oil . .	P. L. .	9,600	7th March 1923	1 year.
Do. .	(15) Do. . .	Do. . .	P. L. .	7,719·04	Do. .	Do.
Do. .	(16) Do. . .	Do. . .	P. L. .	4,313·60	Do. .	Do.
Do. .	(17) Messrs. Whitehall Petroleum Corporation, Ltd.	Do. . .	P. L. .	8,857·60	14th April 1923.	Do.
Do. .	(18) Do. . .	Do. . .	P. L. .	6,400	Do. .	Do.
Do. .	(19) Messrs. Bulloch Bros. & Co.	Do. . .	P. L. (renewal).	11,520	15th September 1923.	Do.
Do. .	(20) Do. . .	Do . .	P. L. (renewal).	24,960	Do. .	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BIHAR AND ORISSA.

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term
Hazaribagh.	(21) Messrs. Nand Samont & Co.	Mica	M. L.	910	30th January 1923.	30 years
Do.	(22) Messrs. F. F. Christien & Co., Ltd.	Do.	M. L.	40	1st September 1923.	Do
Sambalpur.	(23) Seth Puranmal Marwari.	Mica	P. L	114·28	20th February 1923	1 year
Do.	(24) Diwan Bahadur Seth Ballabh Das, Manno Lal and Kanhiya Lal	All minerals	P L.	95·2	22nd December 1923.	Do
Do.	(25) Seth Puranmal Marwari	Mica	M L.	57·86	Not yet executed.	30 years.
Santal Parganas.	(26) Bhudhar Chandra De	Coal	M L.	3 94	1st April 1923	2 years
Do	(27) Giris Chandra Mandal.	Do	M L	0 93	Do.	Do
Do.	(28) Jetha Mulji	Do	M L	3	Do.	Do
Do.	(29) Ramrekh Das Marwari	Do	M L.	1 08	Do.	Do
Do.	(30) Jetha Mulji	Do.	M L	5	Do.	Do
Do.	(31) Bhudhar Chandra De and Giris Chandra Mandal	Do	M L	5	Do	Do
Do.	(32) Bhudhar Chandra De	Do	M L	4 27	Do	Do
Do.	(33) Ramrekh Das Marwari	Do	M L.	1	Do	Do
Do	(34) Binod Bihari De	Do	M L	2 15	Do.	Do
Do.	(35) Bansi Ram Marwari	Do	M L	1 9	Do.	Do
Do.	(36) Jamuna Prashad Marwari.	Do	M L	5 04	Do.	Do
Do.	(37) Ganga Ram Marwari.	Do.	M L	5	Do	Do
Do	(38) Do.	Do.	M L.	3·49	Do.	Do
Do.	(39) Bhudhar Chandra De.	Do.	M. L.	1	Do.	Do
Singhbhum.	(40) Babu Mangi Lal Marwari.	Manganese	M L.	153 65	Lease not yet executed.	15 years
Do.	(41) Kalicharan Trivedi.	Chromite	M L.	730	Do.	20 years
Do	(42) Rajani Kanta Pattadar.	Do.	M. L.	400	Do.	Do

P. L. = *Prospecting Licence.* M. L. = *Mining Lease.*

BOMBAY.

District	Grantee	Mineral	Nature of grant	Area in acres	Date of commencement	Term
Belgaum	(43) Mrs T C Boyce	Manganese ore	M L	3.0	1st June 1923	30 years.
Sukkur	(44) Whitehall Petroleum Co, Ltd, Lahore	Mineral oil and its associated hydro carbons	P L	26 [illegible] 17	6th January 1923	1 year
Do	(45) Indo Burma Petroleum Co, Ltd Rangoon	Mineral oil	P L (renewal)	6 [illegible] 21	21st March 1923	Up to 31st August 1924

BURMA

District	Grantee	Mineral	Nature of grant	Area in acres	Date of commencement	Term
Akyab	(46) Messrs The Indo Burma Petroleum Co Ltd	Mineral oil	P L	4 800	19th January 1923	1 year
Do	(47) Do	Do	P L (renewal).	440	1[illegible]th December 1922	2 years
Do	(48) Messrs The Burma Oil Co Ltd	Do	P L	5 620	16th July 1923	1 year
Do	(49) Messrs The Whitehall Petroleum Corporation Ltd	Mineral oil and its associated hydrocarbons	P L	[illegible],120	19th September 1923	Do
Amherst	(50) Maung Tun Maung	Mineral oil	P L	3 840	22nd March 1923	Do
Do	(51) Maung Ba Thet	All minerals (except oil)	P L	640	28th March 1923	Do
Do	(52) Maung Hte	Do	P L	640	22nd January 1923	Do
Do	(53) Mr A C Jeewa	Do	P L (renewal)	640	1[illegible]th March 1923	Do
Do	(54) Mr P T Peters	Mineral oil	P L	6 400	22nd May 1923	Do
Do	(55) Saw Lu Hoke	All minerals (except oil)	P L	10	9th April 1923	Do
Do	(56) Dr M Shawloo	Tin ore	M L	640	[illegible]th May 1923	30 years
Do	(57) Maung Saw Maung and Ma Kywe	All minerals (except oil)	P L (renewal)	640	21st March 1923	1 year.
Do	(58) Mr A C Jeewa	Tin ore	M L	640	28th August 1923	30 years
Do	(59) Mr M I Moolla	Oil shale	P L (renewal)	[illegible] 822 4	[illegible]th August 1923	1 year
Do	(60) Messrs Balthazar and Son	Mineral oil	P L	5 760	10th November 1923	Do

P L = *Prospecting Licence* M L = *Mining Lease*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Amherst .	(61) Mr. M. E. Moolla .	Mineral oil and oil shale.	P. L. .	15,520	Application sanctioned. License not yet executed.	2 years.
Do. .	(62) Messrs. E. Solomon & Sons.	Oil shale . .	P. L. .	12,800	Do. .	Do.
Do. .	(63) Maung Saw Maung and Ma Kywe.	Tin ore . .	M. L. .	601·00	18th December 1923.	30 years.
Bhamo .	(64) Messrs. The Tavoy Tin Syndicate, Ltd.	All minerals (except oil and precious stones).	M. L. .	3,232 62	15th September 1920.	Do.
Do. .	(65) Do. . .	All minerals (except mineral oil and jade).	P. L. . (renewal).	3,328	4th June 1923	1 year.
Henzada .	(66) Mr. L. D'Attaides .	Mineral oil . .	P. L. .	640	13th January 1923.	Do.
Do. .	(67) Do. . .	Iron pyrite .	M. L. .	236·8	17th May 1923.	30 years.
Do. .	(68) Messrs. The Henzada Development Co., Ltd.	Coal . . .	P. L. .	4,640	18th October 1923.	1 year
Katha .	(69) Ma Shwe Bwin .	All minerals (except oil).	P. L. .	640	23rd March 1923.	Do.
Do. .	(70) Ko Ko Gyi . .	Graphite . .	M. L. .	1,820	23rd February 1923.	30 years.
Do. .	(71) Ma Ma . . .	All minerals (except oil).	P. L. (renewal).	2	21st March 1922.	1 year.
Do. .	(72) Do. . .	Do. . .	P. L. . (renewal).	1,600	1st September 1923.	Do.
Do. .	(73) Maung Shu Maung	Do. . .	P. L. . (renewal).	960	7th December 1923.	Do.
Lower Chindwin.	(74) Maung Ya Hla .	Mineral oil . .	P. L. .	3,200	16th January 1923.	Do.
Do. .	(75) Messrs. Frank Johnson Sons & Co., Ltd.	Do. . .	P. L. .	5,241·60	30th April 1923.	Do.
Do. .	(76) Messrs. Balthazar & Son.	Do. . .	P. L. .	13,440	27th August 1923.	Do.
Do. .	(77) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L .	1,020	16th July 1923.	Do.
Do. .	(78) Do. . .	Do. . .	P. L. . (renewal).	8,576	24th September 1923.	Do.
Do. .	(79) Do. . .	Do. . .	P. L. . (renewal).	9,600	29th November 1923.	Do.
Do. .	(80) Ma Ma . . .	Do. . .	P. L. . (renewal).	910	14th December 1922.	Do.
Do. .	(81) Mr. M. L. Dawson .	Do. . .	P. L. . (renewal).	3,008	30th November 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Magwe .	(82) Mr. W. R. Smith .	Mineral oil .	P. L. .	1,920	27th February 1923.	1 year.
Do. .	(83) Hashim Esoof Malam	Do. . .	P. L. (renewal).	640	20th August 1922.	Do.
Do. .	(84) E. Solomon & Sons	Do. . .	P. L. (renewal).	640	14th July 1922.	Do.
Do. .	(85) Maung Maung Pe .	Do. . .	P. L. (renewal).	1,280	16th November 1922.	Do.
Do. .	(86) Mr. A. Rahman .	Do. . .	P. L. (renewal).	3,840	16th January 1923.	Do.
Do. .	(87) Jaffarally Tar Mahomed.	Do. . .	P. L. (renewal).	640	5th December 1922.	Do.
Do. .	(88) Maung Po San .	Do. . .	P. L. (renewal).	640	20th February 1923.	Do
Do. .	(89) Mr. J. W. H. Fenner	Do. . .	P. L. .	2,560	26th April 1923.	Do.
Do. .	(90) Maung Po San .	Do. . .	P. L. .	2,560	6th May 1923	Do.
Do. .	(91) Messrs. The Union Oil Co.	Do. . .	P. L. .	3,840	15th June 1923.	Do.
Do. .	(92) Maung Po San .	Do. . .	P. L. .	760	13th June 1923.	Do.
Do. .	(93) Abdul Rahman .	Do. . .	M. L. .	640	4th May 1923	30 years.
Do. .	(94) Maung Mo Thaung	Do . .	P. L. .	640	24th April 1923	1 year.
Do. .	(95) Messrs. The Irrawaddy Petroleum Oil Syndicate.	Do. .	P. L. (renewal)	1,920	12th March 1923.	2 years.
Do. .	(96) J. Tar Mahomed .	Do. . .	P. L. (renewal)	3,040	12th April 1923.	Do.
Do. .	(97) Maung Po Tun .	Do . .	P. L. (renewal)	1,280	7th June 1923	Do.
Do. .	(98) Mr. E. E. Moolla .	Do. . .	P. L. (renewal)	100	18th June 1923	Do.
Do. .	(99) Mr. A. Rahman .	Do. . .	P. L. (renewal)	1,200	23rd July 1923.	1 year.
Do. .	(100) Mr. A. E. Mayet .	Do. . .	P. L. (renewal).	1,040·50	29th September 1923	Do
Do. .	(101) Mr. E. E. Moolla .	Do. . .	P. L. (renewal).	100	1st August 1923	Do.
Do. .	(102) Messrs. The Indo-Burma Petroleum Co.	Do. . .	P. L. (renewal).	7,680	25th August 1922	2 years.
Do. .	(103) Mr. Abdul Rahman	Do. . .	P. L. (renewal)	1,440	6th August 1923.	1 year.
Do. .	(104) Do. .	Do. . .	P. L. (renewal).	3,200	25th August 1923.	Do.

P. L. = *Prospecting Licence.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Magwe .	(105) Mr. E. Solomon .	Mineral oil . .	P. L. (renewal).	640	17th August 1923.	2 years.
Do. .	(106) Mr Abdul Rahman	Do. . .	P. L. (renewal).	640	25th August 1923.	1 year.
Do .	(107) Maung Po Aung	Do. . .	P L (renewal)	480	2nd October 1923.	Do.
Do. .	(108) Maung Po Tun .	Do. . .	P L .	100	10th November 1923.	Do
Do. .	(109) Maung Ye .	Do . .	P. L .	640	Do .	Do.
Do. .	(110) Mr. W R Smith	Do. . .	P. L.	626	25th October 1923.	Do.
Do. .	(111) Mr. E. E Moolla	Do. .	P L .	100	15th November 1923.	Do.
Do. .	(112) Messrs. The Upper Burma Oil Syndicate.	Do .	P L	2,880	1st December 1923	2 years
Do. .	(113) Maung Po San .	Do . .	P L (renewal).	640	20th February 1923.	1 year.
Do. .	(114) Maung Kyan Baw	Do. .	P L (renewal)	1,280	2nd March 1923	2 year
Do. .	(115) Messrs. The Burma Oil Co	Do .	P L (renewal)	1,200	12th September 1923.	Do.
Mandalay .	(116) Messrs Steel Bros & Co, Ltd	All minerals (except oil).	P L. (renewal).	2,560	1st October 1922.	1 year
Mergui .	(117) Maung Choon .	Tin and allied minerals	P L .	271 36	5th February 1923.	Do
Do .	(118) Md Esoof Bhymeah	Tin . . .	M L .	317·44	6th January 1923	30 years.
Do. .	(119) Mr C Chan Shwe	Do. . .	M. L. .	1,351·68	11th January 1923	Do
Do. .	(120) Mr D D Mukerji	Do . .	P L. .	2,304	4th November 1922.	1 year
Do .	(121) Mr G H Hand .	Tin and allied minerals.	P. L .	542 72	22nd July 1922	Do
Do .	(122) Mr A M G Forbes	Tin . . .	P L .	1,131 52	26th February 1923.	Do
Do .	(123) Maung Kyin Bu .	Do . . .	M L. .	424 96	27th January 1923	30 years
Do .	(124) Mr Jas. McGregor	Tin and allied minerals.	P. L .	660·48	2nd January 1923.	1 year.
Do. .	(125) Maung Po. Thaik	Tin . . .	M. L. .	491 52	23rd January 1923.	30 years
Do. .	(126) Maung Po . .	Tin and allied minerals.	M. L. .	665·6	3rd March 1923.	Do
Do. .	(127) Mr. A S. Mahomed.	Tin . . .	P. L. .	614	12th February 1923.	1 year.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District	GRANTEE.	Mineral.	Nature of grant	Area in acres	Date of commencement	Term.
Mergui .	(128) Mr. A. S. Mahomed	Tin . .	M. L. .	256	20th January 1923.	10 years.
Do .	(129) Maung Po . .	Tin and allied minerals.	M. L. .	266·21	31st January 1923	30 years.
Do .	(130) Maung San Dun .	Do. .	P. L.	281·60	16th March 1923	1 year
Do .	(131) Maung Choon	Tin . . .	M. L. .	201·84	11th January 1923	30 years.
Do .	(132) Aung Sein Swal .	Tin and Wolfram	M. L. .	1,418·24	20th February 1923	Do.
Do .	(133) Mr. T. Greenhow .	All minerals (except oil)	P. L. . (renewal).	3,082·24	14th July 1921.	2 years.
Do .	(134) Mr. V.A.R. Sutherland.	Cassiterite and gold.	P. L. . (renewal).	640	21st July 1922.	1 year.
Do .	(135) Maung San Dun .	Wolfram, tin and allied minerals.	P. L. . (renewal).	1,120·0	26th October 1922.	Do.
Do	(136) Mr. Chan Khain Lock.	All minerals (except oil)	P. L. . (renewal).	2,180·24	13th October 1922.	Do
Do	(137) Messrs. The Burma Finance and Mining Co., Ltd.	Mineral oil and coal.	P. L. . (renewal).	3,917·52	16th May 1921	2 years.
Do .	(138) Do. .	Do. .	P. L. . (renewal).	2,329·60	Do.	Do.
Do	(139) Mr. A. C. Martin	All minerals (except oil).	P. L. . (renewal).	2,060·80	27th October 1922	1 year.
Do .	(140) Saw Lein Lee .	Tin and allied minerals.	P. L. . (renewal).	640	2nd November 1922.	Do.
Do	(141) Mr. J. T. Doupe .	Tin . . .	P. L. . (renewal).	1,075·20	8th December 1922.	Do.
Do	(142) Do. .	Do. .	P. L. . (renewal).	1,287·68	Do. .	Do.
Do .	(143) Mr. A. S. Mahomed.	Tin and allied minerals	P. L. . (renewal).	704	20th December 1922	Do
Do .	(144) Messrs. Morgan and Holmes.	All minerals (except oil).	P. L. .	1,192·96	5th February 1923	Do.
Do .	(145) Mr. A. C. Campbell Rogers.	Tin . . .	P. L. .	1,126·40	9th January 1923	Do.
Do .	(146) Maung San Mae .	Do. . . .	P. L. .	1,123·36	16th June 1923.	Do.
Do .	(147) Maung Pan On .	Do. . . .	M. L. .	216·22	20th March 1920.	30 years.
Do .	(148) Lim Shain . .	Tin Ore .	M. L. .	450·56	22nd March 1923.	Do.
Do .	(149) Charles Ellis .	Do. . .	M. L. .	731·72	17th April 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term
Mergui .	(150) Messrs. Wightman & Co.	All minerals (except oil).	M. L. .	4,809·24	9th March 1921.	30 years.
Do. .	(151) Mr. A. C. Campbell Rogers.	Do. .	P. L. . (renewal).	1,873·92	14th January 1922.	1 year.
Do. .	(152) Mr. J. T. Doupe .	Tin . . .	P. L. . (renewal).	640	18th August 1922.	Do.
Do. .	(153) Mr. Geo. W. Bowden.	All minerals (except oil).	P. L. . (renewal).	1,267·20	18th December 1922.	Do
Do. .	(154) Mr. V. A. P. Sutherland.	Tin and allied minerals.	P. L. .	4,032	21st June 1923.	Do
Do. .	(155) Mr. J. F. Leslie .	Tin Ore . .	M. L. .	494·86	26th February 1920.	30 years.
Do. .	(156) Mr. Joo Seng .	All minerals (except oil).	P. L. . (renewal).	1,172·48	28th April 1923.	1 year
Do. .	(157) Mr. W. H. Olivant	Do. .	M. L. .	517·12	12th December 1923.	30 years
Do. .	(158) Mr. T. Greenhow .	Tin . . .	M. L. .	215·76	14th March 1922.	Do
Do. .	(159) Mr. S. O. Holmes	Coal . . .	P. L. .	2,201·80	30th November 1923.	1 year
Do. .	(160) Mr. S. V. Norris .	Tin . . .	P. L. .	537·60	10th October 1923.	Do
Do. .	(161) Maung San Dun .	Tin and allied minerals.	P. L. .	128	4th December 1923.	Do
Do. .	(162) Mr. Joo Seng .	Tin Ore . .	P. L. .	35 840	3rd November 1923.	Do
Do. .	(163) Mr. M. Hanlff .	Do. . .	P. L. .	488·96	27th November 1923.	Do
Do. .	(164) The Austral Malay Tin, Ltd.	Do. . .	P. L. .	2,135 14	1st December 1923.	Do
Minbu .	(165) Messrs. The British Burma Petroleum Co., Ltd.	Mineral oil . .	P. L. .	96·60	1st November 1922.	Do
Do. .	(166) Do. .	Do. .	M. L. .	636	9th February 1923.	30 years
Do. .	(167) Messrs. The Burma Finance and Mining Co., Ltd.	All minerals including mineral oil.	P. L. .	5,760	12th November 1922.	1 year
Do. .	(168) Do. .	Do. .	P. L. .	4,160	14th November 1922.	Do.
Do. .	(169) Messrs. The Indo-Burma Oil-fields Ltd.	Mineral oil .	P. L. .	1,288	30th November 1922.	Do.
Do. .	(170) Messrs. The British Burma Petroleum Co., Ltd.	Do. .	P. L. .	1,926·85	5th January 1923.	Do.
Do. .	(171) Do. .	Do. .	M. L. .	556	28th February 1923.	30 years

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Minbu	(172) Messrs. The Irrawaddy Petroleum Oil Syndicate.	Mineral oil	P. L. (renewal).	2,370	16th July 1922.	2 years.
Do.	(173) Mr. S. K. Osmany	Do.	P. L. (renewal).	1,280	21st September 1922.	Do.
Do.	(174) Mr. J. A. Tar Mahomed.	Do.	P. L.	4,568	21st November 1922.	1 year.
Do.	(175) Maung Ba Thi	Coal and mineral oil.	P. L.	220	20th March 1923.	Do.
Do.	(176) Maung U Kin	Mineral oil	P. L.	320	7th February 1923.	Do.
Do.	(177) Do.	Do.	P. L.	160	Do.	Do.
Do.	(178) Maung Po Khi	Do.	P. L.	435·60	24th January 1923.	Do.
Do.	(179) Messrs. The Indo-Burma Oil-fields, Ltd.	Do.	P. L.	223·6	13th February 1923.	Do.
Do.	(180) Messrs. The Burma Oil Co., Ltd.	Do.	P. L. (renewal).	640	23rd January 1923.	2 years.
Do.	(181) D. M. Akhoon	Do.	P. L. (renewal).	320	23rd December 1922.	Do.
Do.	(182) Maung Po Khin	Do.	P. L.	1,900	21st February 1923.	1 year.
Do.	(183) Maung Aung Ba	Do.	P. L.	2,920	17th May 1923.	Do.
Do.	(184) Do.	Do.	P. L.	1,923	Do.	Do.
Do.	(185) Mr. D. M. Akhoon.	Do.	P. L. (renewal).	1,280	18th May 1923.	2 years.
Do.	(186) Mr. Esmail E. Esmail.	Do.	P. L.	320	5th October 1923.	1 year.
Do.	(187) Messrs. The British Burma Petroleum Co., Ltd.	Do.	M. L.	636	9th February 1923.	30 years.
Myingyan	(188) Messrs. The Burma Oil Co., Ltd.	Do.	P. L.	1,580·16	20th December 1922.	1 year.
Do.	(189) Maung Net and Maung So Min.	Do.	P. L. (renewal).	100	3rd November 1923.	Do.
Do.	(190) Messrs. The Union Oil Co. of Burma.	Do.	P. L.	6,720	17th September 1922.	Do.
Do.	(191) Messrs. The Burma Oil Co.	Do.	P. L.	2,813·14	22nd December 1922.	Do.
Do.	192) Mr. Baijnath Singh	Do.	P. L. (renewal).	3,200	16th June 1923	Do.
Do.	(193) Messrs. The Burma Oil Co., Ltd.	Do.	P. L. (renewal).	1,004·80	31st July 1923.	2 years.

P.L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Myingyan .	(194) Messrs. The Union Oil Co., Ltd.	Mineral Oil .	P. L. (renewal)	6,720	17th September 1923.	1 year.
Northern Shan States	(195) Messrs. The Burma Corporation Ltd.	Iron Ore . .	P. L. .	640	1st October 1922.	Do.
Do.	(196) Do .	Do. . .	P. L. .	385	1st June 1922	Do.
Do.	(197) Do. .	Do. . .	P. L. (renewal).	160	8th May 1923	Do.
Do.	(198) Messrs The Coal fields of Burma Ltd	All minerals (except oil)	P. L. (renewal).	2,560	1st August 1922.	Do.
Do.	(199) Messrs The Burma Corporation Ltd.	Iron Ore . .	M. L. .	320	1st January 1920.	30 years
Do.	(200) Do .	Do . .	M. L. .	320	Do. .	Do
Do.	(201) Do. .	Do. . .	P. L. (renewal).	385	1st June 1923	1 year
Do.	(202) Messrs The Coalfields of Burma Ltd	All minerals (except oil).	P. L. (renewal).	2,560	1st August 1923	Do.
Pakokku .	(203) Mr. Rowland Ady	Mineral oil . .	P. L. .	2,400	1st August 1922.	Do
Do. .	(204) Mr Colin Campbell	Do. . .	P. L. .	551 4	22nd November 1922.	Do*
Do. .	(205) Ma Zan . .	Do. . .	P. L. .	200 (in Blocks 92 and 97)	16th October 1922.	Do.
Do. .	(206) U Ba Oh . .	Do. . .	P. L. .	3,276 8	30th November 1922.	Do.
Do. .	(207) Maung Hmon and Maung Thin	Do. . .	P. L. (renewal).	320	31st August 1922	Do.
Do. .	(208) Do .	Do. . .	P. L. (renewal).	100	Do. .	Do.
Do. .	(209) Messrs. The Burma Oil Co	Do. . .	P. L. (renewal).	800	17th November 1922.	2 years.
Do. .	(210) Mr Ebrahim .	Do .	P. L. .	640	15th August 1923.	1 year
Do. .	(211) Messrs. The Nath Singh Oil Co.	Do. . .	P. L. (renewal).	14,400	27th November 1921.	2 years
Do. .	(212) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. (renewal)	800	4th February 1922.	Do.
Do. .	(213) Bajnath Singh .	Do. . .	P. L. (renewal).	2,400	28th March 1922.	Do.
Do. .	(214) Ma Zan . .	Do. . .	P. L. (renewal)	100	30th June 1922.	Do.
Do. .	(215) Messrs. The British Burma Petroleum Co., Ltd.	Do. . .	P. L. .	640 acres in Block 138 of Yenangyat Oilfield.	15th August 1923.	1 year

P. L.—*Prospecting License.* M. L.—*Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement	Term.
Pakokku .	(216) Maung Aung Ba .	Mineral oil . .	P. L. .		Applications sanctioned in November 1923 Licenses not yet executed.	
Do. .	(217) Messrs. The Nath Singh Oil Co., Ltd.	Do. . .	P. L. .			
Prome .	(218) Maung Bo Ni .	Do. . .	P. L. (renewal).	46 08	22nd December 1922.	1 year
Do. .	(219) Maung Aung Gyaw	Do. . .	P. L. .	640	29th September 1923.	Do.
Do. .	(220) G. Govindram .	Do. . .	P. L. (renewal).	110 08	22nd February 1923.	Do.
Do. .	(221) Maung Bo Ni .	Do. . .	P. L. (renewal).	640	28th March 1923.	Do.
Do. .	(222) Mr. Arthur Daires .	Do . .	P. L. .	8,320	10th October 1923.	Do.
Do. .	(223) Ismail Aboo Ahmed	All minerals (except amber, jade and jadeite)	P. L. .	4,441 60	18th December 1923.	Do
Do. .	(224) Messrs. Balthazar & Sons.	Mineral oil . .	P. L. .	9,398 16	Do	Do.
Do .	(225) Mr. Abdulla .	All minerals (except amber, jade and jadeite)	P. L. .	2,560	15th December 1923	Do
Do .	(226) Maung Aung Nyein	Mineral oil . .	M. L. .	409 60	24th November 1923	30 years.
Do. .	(227) Maung Shwe Bwa.	Do. . .	P. L. (renewal).	640	25th May 1923.	1 year
Shwebo .	(228) Messrs. Frank Johnson Sons & Co., Ltd.	Do. . .	P. L.	5,036 80	9th May 1923	Do.
Do .	(229) Do. .	Do . .	P. L. .	7,080	Do	Do
Do. .	(230) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. .	2,560	23rd May 1923	Do
Do. .	(231) Do. .	Do. . .	P. L .	18,560	31st August 1923	Do
Do. .	(232) Messrs The Burma Oil Co., Ltd.	Do. . .	P. L. .	4,518 40	25th September 1923	Do
Do. .	(233) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. .	9 280	14th August 1923	Do
Do. .	(234) Messrs. The Coalfields of Burma Ltd.	All minerals (except oil).	P. L. (renewal).	1,920	18th February 1923	Do.
Do. .	(235) Ismail Esoof Kaka	Coal . .	P. L. .	1,920	23rd November 1923.	Do.
Southern Shan States.	(236) Mr. Lim Chin Tsong.	Lead . . .	P. L. (renewal).	40	5th February 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Southern Shan States.	(237) Capt. J. P. K. Wilkins.	All minerals (except oil).	P. L. .	2·72	26th April 1923.	1 year.
Do. .	(238) Sir J. G. Scott .	Gold, Copper, etc.	P. L. (renewal).	5,440	9th May 1923	2 years
Do. .	(239) Do. .	Do .	P. L. (renewal).	640	Do. .	Do.
Do. .	(240) Mr R. B. Neville .	All minerals (except oil).	P. L. .	1,120	6th December 1923.	1 year
Do. .	(241) Messrs Steel Bros.	Do. .	P. L .	80	3rd December 1923.	Do
Do. .	(242) Do.	Do. .	P. L. .	224	Do. .	Do
Do. .	(243) Mr. J. W. Ryan .	Do. .	P. L .	503 25	5th September 1923.	Do
Do. .	(244) Messrs. Steel Bros.	Do. .	P. L .	2,500	27th November 1923.	Do.
Do. .	(245) Do. .	Do. .	P. L. .	2,370	15th October 1923.	Do.
Do. .	(246) Do. .	Do. .	P. L . (renewal).	18 153	1st April 1923	2 years.
Tavoy .	(247) Ong Hae Kyin .	Wolfram and tin	M. L .	627	8th March 1923.	30 years.
Do. .	(248) Messrs The Indo-Burma Tin Corporation Ltd.	Do. .	M. L. .	3·90	17th March 1923.	Do.
Do. .	(249) Do. .	All minerals (except oil).	P. L. .	144	30th January 1923.	1 year
Do. .	(250) Mr. M. T. Dunstan	Do. .	P. L. .	1,763 10	31st January 1923.	Do.
Do. .	(251) Ma Yai . .	Tin and Wolfram	P. L. .	305 92	20th January 1923.	Do
Do. .	(252) Mr. R. C. N. Twite.	Tin and allied minerals	P. L. .	117	30th January 1923.	Do
Do. .	(253) Lee Taik Seong .	Tin and Wolfram.	P. L. .	293 08	10th January 1923.	Do.
Do. .	(254) H. Kim Chu .	Tin and allied minerals.	P. L. .	579	19th February 1923.	Do
Do. .	(255) Mr. J. M. Manckji	Do. .	P. L. . (renewal).	1,106	27th October 1922.	Do.
Do. .	(256) Mr. G. Lovell .	Tin and Wolfram	P. L. .	218	17th April 1923.	Do.
Do. .	(257) Maung Maung .	Do. .	P. L. .	640	25th May 1923	Do.
Do. .	(258) Messrs. Tavoy Tin Syndicate, Ltd.	Tin and allied minerals.	M. L. .	817 53	27th August 1920.	30 years
Do. .	(259) Quah Cheng Tock.	Wolfram, tin and allied minerals.	M. L. .	657	18th April 1923.	Do.

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BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(260) Maung Po Swe	Wolfram and tin	M. L.	492	20th April 1923.	5 years.
Do.	(261) Maung Maung	Do.	M. L.	640	17th April 1923.	30 years.
Do.	(262) Mr. G. Lovell	Do.	P. L. (renewal).	123	13th January 1923.	1 year.
Do.	(263) Mr. J. J. A. Page	Do.	P. L. (renewal)	210	26th April 1923.	Do.
Do.	(264) Mr. M. T. Dunstan	Do.	P. L.	1,088	6th July 1923	Do.
Do.	(265) Mr. H. Kim Chu	Tin and allied minerals.	P. L.	390	21st September 1923.	Do.
Do.	(266) Mr. J. J. A. Page	Tin	P. L.	154	10th September 1923.	Do.
Do.	(267) Maung Ni Toe	All minerals (except oil).	P. L.	323	17th August 1923.	Do.
Do.	(268) Messrs. The Indo-Burma Tin Corporation Ltd.	Tin	P. L.	12·5	21st August 1923.	Do.
Do.	(269) Ong Hoe Kyin	Tin and Wolfram	P. L.	614	10th September 1923.	Do.
Do.	(270) Messrs. Steel Bros. & Co., Ltd.	All minerals (except oil).	M. L.	61·41	1st February 1919.	30 years.
Do.	(271) Md. Aslam Khan	Do.	M. L.	483	24th March 1919.	Do.
Do.	(272) Mr. G. Willison	Tin and Wolfram	P. L. (renewal).	640	5th May 1923	1½ years.
Do.	(273) Maung Ba Oh	All minerals (except oil).	P. L. (renewal)	632	23rd June 1923.	1 year.
Do.	(274) Maung Ni Toe	Do.	P. L. (renewal).	116	31st July 1923.	Do.
Do.	(275) Mr. M. T. Dunstan	Tin and Wolfram	P. L.	170	1st October 1923.	Do.
Do.	(276) Mr. A. Sheard	Tin and other minerals.	P. L.	1,280	30th November 1923.	Do.
Do.	(277) Do.	Do.	P. L.	1,920	Do.	Do.
Do.	(278) Do.	Do.	P. L.	1,920	Do.	Do.
Do.	(279) Mr. H. Kim Chu	Tin and allied minerals.	P. L.	637	18th December 1923.	Do.
Do.	(280) Maung Po Myee	All minerals (except oil).	P. L. (renewal).	570	18th June 1923.	Do.
Tharrawaddy.	(281) Maung Aung Nyun	Mineral oil	P. L.	640	22nd August 1923.	Do.
Thaton	(282) Maung Pu	Tin	P. L. (renewal).	505·6	2nd February 1923.	Do.

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BURMA—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Thayetmyo.	(283) Mr. Ismail Abu	Mineral oil	P. L.	2,880	15th January 1923.	1 year
Do.	(284) Golabroy Govindaram.	Do.	P. L.	640	8th December 1922.	Do
Do.	(285) Do.	Do.	P. L.	640	Do.	Do
Do.	(286) Ismail Abu Ahmed	Do.	P. L.	2,240	15th January 1923.	Do
Do.	(287) Omar Abu Bucker	Do.	P. L.	2,560	23rd February 1923.	Do
Do.	(288) Messrs. Frank Johnson Sons & Co., Ltd.	Do	P. L.	3,840	9th February 1923.	Do
Do.	(289) Messrs. The Indo-Burma Oil-fields (1920) Ltd.	Do.	M. L.	320	8th March 1923.	30 years
Do.	(290) Messrs. Frank Johnson Sons & Co., Ltd.	Do.	P. L.	524·8	8th February 1923.	1 year
Do.	(291) Golabroy Govindaram.	Do.	P. L.	3,200	8th December 1922.	Do
Do.	(292) Omar Abu Bucker	Do.	P. L.	2,400	23rd March 1923.	Do.
Do.	(293) Mr. Colin Campbell	Do.	P. L.	2,095·20	16th January 1923.	Do.
Do.	(294) Mr. Rowland Ady	Do.	P. L.	3,008	13th January 1923.	Do.
Do.	(295) Messrs. The Indo-Burma Oil-fields Ltd.	Do.	P. L. (renewal).	2,560	12th July 1922.	Do.
Do.	(296) Do	Do	P. L. (renewal).	4,800	6th October 1922.	Do.
Do.	(297) Do.	Do.	P. L. (renewal).	2,560	14th December 1922.	Do.
Do.	(298) Do.	Do	P. L. (renewal).	6,880·4	23rd January 1923.	Do.
Do.	(299) Ismail Aboo Ahmed	Do.	M. L.	320	12th May 1923	30 years
Do.	(300) Mr. D. M. Akhoon.	Do.	P. L.	640	2nd July 1923.	1 year
Do.	(301) Messrs. The Indo-Burma Oil-fields (1920) Ltd.	Do.	P. L.	18,496	26th April 1923.	Do
Do.	(302) Yeo Eng Byah	Do.	P. L.	1,312	5th July 1923.	Do
Do.	(303) Mr. Colin Campbell	Do.	P. L.	1,425	11th July 1923.	Do
Do.	(304) Ma Thein Yin	Do.	P. L.	3,200	20th July 1923.	Do.
Do.	(305) Messrs. The Indo-Burma Oil-fields (1920) Ltd.	Do.	P. L. (renewal).	11,840	12th March 1923.	Do.

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BURMA—*concld.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Thayetmyo	(306) Messrs. The Indo-Burma Oil-fields (1920), Ltd.	Mineral oil .	P. L. (renewal).	5,945·60	15th February 1923.	1 year.
Do. .	(307) Do.	Do. . .	P. L. (renewal).	2,560	12th July 1923.	Do.
Do. .	(308) Maung Hme Bu .	Do. . .	P. L. .	100	15th September 1923.	Do.
Do. .	(309) Golabroy Govindram.	Do. . .	P. L. .	100	20th September 1923.	Do.
Do. .	(310) Maung Hme Bu .	Do. . .	P. L. .	100	15th September 1923	Do.
Do. .	(311) Messrs. The Indo-Burma Oilfields, Ltd.	Do. . .	P. L. .	5,235·20	3rd September 1923.	Do.
Do. .	(312) Chwa Maung Tike	Do. . .	P. L. .	100	12th October 1923.	Do.
Do. .	(313) Messrs. The Indo-Burma Oil fields (1920) Ltd.	Do. . .	P. L. .	30,720	Application sanctioned. License not yet executed	2 years
Do. .	(314) Messrs. The Union Oil Co., Ltd.	Do. . .	P. L. (renewal).	3,71 20	14th September 1923.	1 year.
Do. .	(315) Maung Tun Aung Gyaw.	Do. . .	P. L. (renewal).	60	20th September 1923.	Do.
Upper Chindwin.	(316) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. .	2,816	30th January 1923.	Do.
Do. .	(317) Messrs. The Indo-Burma Petroleum Co., Ltd	Do. . .	P. L. (renewal).	12,800	12th September 1922.	Do.
Do. .	(318) Messrs. The Coal-fields of Burma, Ltd.	Coal . . .	P. L. (renewal).	2,188·8	31st August 1922.	Do.
Do. .	(319) Do.	Do. . . .	P. L. (renewal).	1,632	15th September 1922.	Do.
Do. .	(320) Do.	Do. . . .	P. L. (renewal).	10,284·8	26th November 1922.	Do.
Do. .	(321) Messrs. Frank Johnson Sons & Co., Ltd.	Mineral oil . .	P. L. (renewal).	3,078·40	26th October 1922.	Do.
Do. .	(322) Messrs. The Burma Oil Co., Ltd.	Do. . .	P. L. .	1,760	28th August 1923.	Do.
Do. .	(323) Messrs. Frank Johnson Sons & Co., Ltd.	Do. . .	P. L. (renewal).	2,240	2[illegible]th January 1923.	Do.
Do. .	(324) Messrs. The Coal-fields of Burma Ltd.	Mineral oil and coal.	P. L. (renewal).	3,264	Do.	Do.
Do. .	(325) Do.	Do.	P. L. (renewal).	7,584	14th January 1923.	Do.
Do. .	(326) Do.	Do.	P. L. (renewal).	1,824	7th February 1922.	2 years.
Do. .	(327) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral oil . .	P. L. (renewal).	3,200	24th May 1921	1 year.

P. L. = *Prospecting License* M. L. *Mining Lease*

CENTRAL PROVINCES.

District	GRANTEE	Mineral.	Nature of grant	Area in acres.	Date of commencement.	Term
Balaghat .	(328) The Indian Manganese Co., Ltd	Manganese . .	M. L. .	15	30th January 1923.	20 years
Do. .	(329) Messrs. B. N. Soparkar & Co.	Do. . .	M. L. .	19	23rd March 1923.	23 years 9 months and 4 days
Do. .	(330) Seth Permanand Saroopchand	Do .	P. L. .	385	15th January 1923.	1 year
Do. .	(331) Messrs. Ramprasad Laxmi Narayan	Do . .	P. L.	40	29th March 1923	Do
Do. .	(332) Central India Mining Co., Ltd	Do. . .	M. L. .	1	29th January 1923.	2 years
Do. .	(333) Messrs. B. P. Byramji & Co.	Do . .	M. L. .	35	8th May 1923	15 years
Do. .	(334) Do.	Do . .	P. L.	134	29th June 1923.	1 year
Do. .	(335) Messrs. Lalbehari Narayandas and Ramcharan Shankerlal	Do .	M. L.	12	23rd March 1923	15 years
Do. .	(336) Messrs. Balkrishna Narayan & Co.	Do .	M. L. .	21	9th June 1923	30 years
Do .	(337) Do	Do . .	P. L.	125	26th June 1923	1 year
Do. .	(338) Mr. C. S. Harris .	Do . .	M. L. .	25	12th June 1923	30 years
Do. .	(339) Messrs. Ramprasad Laxmi Narayan	Do . .	P. L. .	36	18th June 1923	1 year
Do. .	(340) Mr. Sunderlal Golcha	Do . .	P. L. .	113	Do	Do
Do. .	(341) Rai Sahib Gowardhan Das	Do . .	P. L.	71	20th June 1923	Do
Do. .	(342) Pandit Rewashanker	Do . .	P. L. .	120	29th June 1923	Do
Do.	(343) Do.	Do . .	M. L. .	18	27th June 1923	10 years
Do. .	(344) Messrs. Ramprasad Laxmi Narayan.	Do . .	P. L. .	219	27th July 1923	1 year.
Do. .	(345) Pandit Kripashanker	Do. . .	M. L.	48	12th July 1923.	15 years
Do. .	(346) Do.	Do. . .	P. L. .	181	20th July 1923.	1 year
Do. .	(347) Do.	Do. . .	M. L. .	57	1st August 1923.	15 years
Do. .	(348) Messrs. Lalbehari Narayandas and Ramcharan Shankerlal.	Do. . .	P. L. .	25	20th July 1923.	1 year.
Do. .	(349) Do	Do. . .	P. L. .	18	Do.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat	(350) Messrs. Balkrishna Narayan & Co.	Manganese	P. L.	43	2[illegible]th July 1923.	1 year.
Do.	(351) Mr. Balkrishna Narayan Soparker.	Do.	P. L.	30	16th August 1923.	Do.
Do.	(352) Pandit Rewashanker.	Do.	P. L.	13	17th September 1923.	Do.
Do.	(353) Messrs Bahmansha Fourdar Bros.	Mica	P L.	40	11th September 1923.	Do
Do.	(354) Mr. Sunderlal Golcha.	Manganese	P L.	2	31st August 1923.	Do.
Do	(355) Rai Sahib Narayandas Khushalram.	Do.	P. L.	13	20th July 1923	Do.
Do	(356) The Central India Mining Co.	Do.	P. L.	12	31st August 1923	Do.
Do.	(357) Messrs. Martin & Co.	Do.	P L.	272	17th September 1923.	Do.
Do	(358) Rai Sahib Seth Gowardhandas.	Do.	P. L.	52	3rd August 1923.	Do.
Do.	(359) Seth Sarupchand	Do.	P. L.	17	21st October 1923.	Do.
Do.	(360) Do.	Do.	P. L.	70	25th October 1923.	Do.
Do	(361) Pandit Rewashanker.	Do.	M L.	45	16th October 1923.	10 years.
Do	(362) Do.	Do.	P. L	133	19th November 1923.	1 year.
Do.	(363) Do.	Do.	P L.	158	Do	Do.
Do.	(364) Messrs. B. P. Byramji & Co.	Do.	M. L.	5	1st November 1923.	5 years
Do.	(365) Messrs. B N. Soparker & Co.	Do.	M. L.	14	11th October 1923	30 years
Do.	(366) Messrs. Tata Sons, Ltd.	Do.	M. L.	600	1st November 1923	Do.
Do.	(367) Pandit Kripashanker.	Do.	P L.	23	31st October 1923	1 year.
Do.	(368) Mr. Sunderlal Golcha.	Do.	P. L.	90	30th November 1923.	Do.
Do.	(369) Do.	Do.	P. L.	85	16th November 1923.	Do.
Do.	(370) Seth Chagmal Kachar.	Do.	P. L.	85	5th October 1923.	Do.
Do.	(371) Do.	Do.	P. L.	88	10th November 1923.	Do.

P. L.—*Prospecting License.* M. L.—*Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(372) R. S. Narsingdass .	Mica . . .	P. L. .	42	5th October 1923.	1 year.
Do. .	(373) Do. . .	Manganese . .	P. L. .	15	Do.	Do.
Do. .	(374) Mr. C. Stanley Harris.	Do. . .	P. L. .	100	16th November 1923.	Do.
Do. .	(375) M. B. Chopra .	Do. . .	P. L. .	53	30th November 1923.	Do.
Betul .	(376) Mr. W. M. Moylon	Coal . . .	P. L. .	240	3rd January 1923.	Do.
Do. .	(377) Messrs. Bisheswarlal and Jagannath.	Do. . . .	P. L. .	475	12th March 1923.	Do.
Do. .	(378) Mr. Damji Deosi .	Do. . . .	P. L. .	33	8th January 1923.	Do.
Do. .	(379) Seth Girdharilal, Banker.	Do. . .	P. L. .	516	5th February 1923.	Do.
Do. .	(380) Patel Keshoram .	Do. . . .	P. L. .	168	24th March 1923.	Do
Do. .	(381) Hazi Zahiruddin .	Do. . . .	P. L. .	282	3rd January 1923.	Do
Do. .	(382) Patel Keshoram .	Do . . .	P. L .	178	24th March 1923.	Do
Do. .	(383) Seth Minamal and Nandlal.	Do. . . .	P. L. .	406	27th February 1923	Do
Do. .	(384) Seth Hazarilal .	Do. . . .	P. L. .	33	1st March 1923	Do.
Do. .	(385) Mr. Dinanath Patel	Iron and ferric-oxide.	P. L .	92	9th January 1923.	Do.
Do. .	(386) Mr. Pratul Narayan Mukerji	Coal . . .	P. L. .	1,481	30th January 1923.	Do
Do. .	(387) Do. . .	Do. . . .	P. L. .	390	24th March 1923.	Do
Do. .	(388) Mr. Nazir Ali Mohammad Ali.	Do. . . .	P. L .	544	20th March 1923.	Do.
Do. .	(389) Thakur Prasad Awasthi.	Do. . . .	P. I. .	52	21st May 1923	Do.
Do. .	(390) Nazarali Mohommadali.	Do. . . .	P. L. .	444	26th May 1923	Do.
Do. .	(391) Do. . .	Do. . . .	P. L. .	365	Do. .	Do.
Bhandara .	(392) Mr. Shamji Narayanji.	Manganese . .	P. L. .	3	2nd February 1923.	Do.
Do. .	(393) Do. . .	Do. . .	P. L. .	10	Do. .	Do.
Do. .	(394) Do. . .	Do. . .	P. L. .	1	Do. .	Do
Do.	(395) Mr. Bansidhar Ramniwas.	Do. . .	P. L. .	151	25th April 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhandara	(396) Mr. Gulam Mohomed.	Manganese	P. L.	172	2nd June 1923.	1 year.
Do.	(397) Rai Sahib Gowardhan Das.	Do.	P. L.	35	30th June 1923.	Do.
Do.	(398) Messrs. B. P. Byramji & Co.	Do.	M. L.	3	8th May 1923	5 years.
Do.	(399) Mr. Sunderlal Golcha.	Do.	P. L.	101	26th July 1923	1 year.
Do.	(400) Seth Karnidan Chogmal.	Do.	P. L.	274	18th July 1923.	Do.
Do.	(401) Do.	Do	P. L.	65	19th August 1923.	Do.
Do.	(402) Rai Sahib Narayandas Khushaliram.	Do.	P. L.	19	11th August 1923.	Do.
Do.	(403) Mr. Shamjee Narayanjee.	Do.	P. L.	29	7th July 1923	Do.
Do.	(404) Do.	Do.	P. L.	1	Do.	Do.
Do.	(405) Messrs Lalbehari Narayandas and Ramcharan Shankerlal	Do	M. L.	36	27th August 1923.	10 years.
Do.	(406) Seth Karnidan Chhogmal.	Do.	P. L.	680	21st October 1923.	1 year.
Do	(407) Manwarali Turabali Syndicate.	Do.	P. L.	278	8th October 1923.	Do.
Do.	(408) Mr. Shriram Seth	Do.	P. L.	15	20th December 1923	Do.
Do.	(409) Mr. Lala Jainarayan.	Do.	P. L.	19	12th November 1923.	Do.
Bilaspur	(410) Messrs. Chari & Co., Calcutta.	Coal	P. L.	1,630	18th January 1923	1 year.
Do.	(411) Capt. W. J. Considine and Messrs. Dunlop Bros. & Co.	Do.	P. L.	11,102	9th March 1923.	Do.
Do.	(412) Do.	Do.	P. L.	3,376	10th November 1923.	Do.
Chanda	(413) Rao Sahib D. Laxmi Narayan.	Do.	M. L.	274	14th June 1923.	30 years.
Do.	(414) Do.	Do.	P. L.	597	3rd April 1923	1 year.
Do.	(415) Do.	Do.	P. L.	1,874	Do	Do.
Do.	(416) Hon'ble Sir M. B. Dadabhoy.	Do.	P. L.	550	11th May 1923	Do
Do.	(417) Rao Sahib D. Laxmi Narayan.	Do.	P. L.	73	28th August 1923.	Do.
Do.	(418) Do.	Do.	P. L.	971	1st October 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chanda .	(419) Rao Sahib D. Laxmi Narayan.	Coal . . .	P. L. .	948	26th November 1923.	1 year.
Chhindwara	(420) Mr. B.V. Buti .	Do. . . .	P. L. .	299	6th January 1923.	Do.
Do. .	(421) Diwan Bahadur Seth Ballabhdas.	Do. . . .	P. L. .	368	5th March 1923.	Do.
Do. .	(422) Seth Hazarilal .	Do. . . .	P. L. .	67	1st March 1923.	Do.
Do. .	(423) Do. . .	Do. . . .	P. L. .	160	3rd January 1923.	Do.
Do. .	(424) Do. . .	Do. . . .	P. L. .	193	Do. .	Do.
Do. .	(425) Sir Bisseswardas Daga.	Manganese . .	P. L. .	7	Do. .	Do.
Do. .	(426) Messrs B. Faujdar Bros.	Do. . .	P. L. .	56	22nd January 1923.	Do.
Do. .	(427) Mr. Bakaram Singh	Do. . .	P. L. .	8	2nd March 1923.	Do.
Do. .	(428) Do. . .	Do. . .	P. L. .	152	Do. .	Do
Do. .	(429) Hazi Zahiruddin .	Coal . . .	P. L. .	51	21st March 1923.	Do
Do. .	(430) Messrs. B. Faujdar Bros.	Manganese . .	P. L .	37	19th February 1923.	Do
Do. .	(431) Rai Sahib Mathura Prasad Motilal & Co	Coal . . .	M L. .	540	3rd January 1923	30 years.
Do. .	(432) Rai Sahib Sunder Lal.	Do. . . .	M. L. .	616	30th January 1923.	Do
Do. .	(433) Seth Laxmichand of Betul.	Do. . . .	M L. .	83	24th February 1923.	Do
Do. .	(434) Rai Sahib Seth Govardhandas.	Do. . . .	M. L. .	146	30th November 1922.	Do
Do. .	(435) Indian Manganese Co.	Manganese . .	M. L. .	26	14th February 1923.	Till 31st May 1932.
Do. .	(436) Rai Sahib A. P. Bhargava.	Coal . . .	P. L. .	160	5th April 1923.	1 year
Do. .	(437) Seth Hazarilal .	Do. . . .	P. L. .	167	7th June 1923	Do
Do.	(438) Mr. Noormohommad.	Do. . . .	P. L. .	133	16th April 1923.	Do
Do.	(439) Hon'ble Sir M. B. Dadabhai.	Manganese . .	P. L. .	41	9th May 1923	Do.
Do. .	(440) Messrs. B. Faujdar Bros.	Do. . .	P. L. .	30	14th June 1923.	Do.
Do.	(441) Do. . .	Do. . .	P. L. .	35	15th June 1923.	Do.
Do.	(442) Do. . .	Do. . .	P. L. .	48	Do. .	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara	(443) Messrs. M. D. Costa & Gouridutt Ganeshlal.	Manganese . .	P. L. .	140	28th June 1923.	1 year.
Do. .	(444) Do. . .	Do. . .	P. L. .	17	9th May 1923	Do.
Do. .	(445) Seth Hazarilal .	Do. . .	P. L. .	10	25th June 1923.	Do.
Do. .	(446) Pandit Kirpa Shanker.	Coal . .	M. L. .	120	29th May 1923	30 years.
Do.	(447) Seth Laxmichand	Do. . . .	M. L. .	68	4th June 1923	Do.
Do. .	(448) Rai Sahib Seth Gowardhandas.	Do. . . .	M. L. .	227	16th April 1923.	Do.
Do. .	(449) Pandit Kirpa Shanker.	Do. . . .	M. L. .	383	29th May 1923	Do.
Do. .	(450) Mr. Banshidhar Ramniwas.	Do. . . .	M. L. .	590	8th May 1923	Do.
Do. .	(451) Haji Zahiruddin .	Do. . .	M. L. .	187	29th May 1923.	Do.
Do. .	(452) Pandit Kedarnath Bhargava.	Do. . . .	P. L. .	126	7th July 1923	1 year.
Do. .	(453) Messrs. Dannulal and others.	Do. . .	P. L. .	148	5th July 1923	Do.
Do. .	(454) Messrs. Abdul Kadir, Abdul Ali and Brothers.	Do. . . .	P. L. .	329	8th August 1923.	Do.
Do .	(455) Rai Sahib Seth Govardhandas.	Do. . . .	P. L. .	67	16th July 1923	Do.
Do. .	(456) Khan Sahib M. Hasanji & Sons.	Manganese . .	P. L. .	102	17th July 1923.	Do.
Do .	(457) Messrs. Dhannoolal and others.	Coal . . .	P. L. .	249	5th July 1923	Do.
Do. .	(458) Rai Sahib Minnamal Nandlal.	Do. . .	P. L. .	320	8th August 1923.	Do.
Do .	(459) Messrs. Abdul Kadir Abdul Ali.	Do. . .	P. L. .	149	3rd July 1923	Do.
Do. .	(460) Messrs. M. D. Costa and Gouridutt Ganeshlal.	Do. . .	P. L. .	176	20th July 1923	Do.
Do. .	(461) Rajnath Dwarkanath.	Do . .	P. L. .	92	18th September 1923.	Do.
Do. .	(462) Chhedilal Chaudhri	Do. . .	P. L. .	340	15th August 1923.	Do.
Do. .	(463) Messrs. B. Faujdar and Brothers.	Manganese . .	P. L. .	21	27th September 1923.	Do.
Do. .	(464) Seth Hazarilal Bazaz.	Do. . .	P. L. .	41	12th July 1923.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara	(465) Seth Hazarilal Bazaz.	Manganese . .	P. L. .	100	3rd July 1923	1 year.
Do. .	(466) Mr A. V. Wazalwar.	Do. . .	P. L. .	60	5th September 1923.	Do
Do. .	(467) Messrs. M D. Costa and Gouri Dutt Ganesh Lal.	Do. . .	P. L. .	7	12th September 1923.	Do
Do. .	(468) Do. . .	Do. . .	P. L. .	49	Do. .	Do
Do. .	(469) Do. . .	Do. . .	P. L. .	52	Do. .	Do.
Do. .	(470) Messrs. Shaw Wallace & Co. *	Coal . . .	M. L. .	3	13th July 1923.	30 years
Do. .	(471) Rai Sahib A. P. Bhargao.	Do. . . .	M. L. .	19	11th August 1923.	Do.
Do. .	(472) Rai Sahib Mathuraprosad, Moti Lal & Co.	Do. . . .	M. L. .	9	30th August 1923.	Do.
Do. .	(473) Seth Hazarimal Bazaz.	Do. . . .	P. L. .	65	4th October 1923.	1 year.
Do. .	(474) Do. . .	Manganese .	P. L. .	11	30th November 1923.	Do
Do. .	(475) Do. . .	Do. . .	P. L. .	65	4th October 1923.	Do
Do. .	(476) Messrs. Abdul Kader Abdullah and Bros.	Do. . .	P. L. .	31	22nd December 1923.	Do.
Do. .	(477) Patel Keshoram .	Coal . . .	P. L. .	118	28th November 1923.	Do.
Do. .	(478) Do. .	Do. . .	P. L. .	174	Do. .	Do.
Do. .	(479) Seth Hazarimal Bazaz.	Manganese . .	P. L. .	13	15th December 1923.	Do.
Do. .	(480) Mr. R. Bazaj .	Coal . . .	M. L. .	307	17th September 1923.	30 years.
Do. .	(481) Sheikh Shahabuddin & Sons.	Do. . . .	M. L. .	75	20th October 1923.	15 years.
Do. .	(482) Indian Manganese Co.	Manganese . .	M. L. .	13	1st November 1923.	Will expire with the mining lease dated 18th November 1914 to which it is supplementary.
Hoshangabad	(483) Seth Hazarilal .	Coal . . .	P. L. .	365	5th July 1923	1 year.
Do. .	(484) Pandit Mrityunjai Prasad Subedar.	Do. . . .	P. L. .	150	9th June 1923	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District	GRANTEE.	Mineral.	Nature of grant	Area in acres	Date of commencement	Term
Hoshangabad	(485) Rai Saheb Seth Jugalkishore.	Coal . . .	P. L. .	232	9th July 1923	1 year.
Do. .	(486) Do. . .	Do. . . .	P. L. .	241	28th July 1923	Do.
Do. .	(487) Rai Sahib A P. Bhargava.	Do. . . .	P. L. .	395	13th December 1923	Do.
Do. .	(488) Debiprosad Benia	Do. . . .	P. L. .	165	10th December 1923	Do.
Jubbulpore.	(489) Tata Electro Chemicals, Ltd.	Bauxite . .	P. L. .	169	24th March 1923	1 year.
Do .	(490) Do. . .	Do. . .	P. L. .	206	25th January 1923	Do.
Do .	(491) Do. . .	Do. . .	P. L .	297	Do. .	Do.
Do .	(492) Mr. G. H. Cook .	Coal . . .	P L. .	575	7th March 1923.	Do
Do. .	(493) Mr. George Forrester.	Bauxite . .	P. L. .	215	25th January 1923.	Do.
Do .	(494) Rai Sahib Jugalkishore.	Coal . . .	P. L. .	406	9th January 1923	Do.
Do. .	(495) Mr. Thakur Prasad Awasthi.	Do. . .	P. L. .	226	12th January 1923.	Do.
Do .	(496) Do. . .	Do. . .	P. L. .	210	Do. .	Do
Do. .	(497) Mr. Venkat Ramanna.	Do. . .	M. L .	36	27th February 1923.	30 years.
Do. .	(498) Olpherts Paints & Products, Ltd.	Manganese, copper, gold and silver.	P. L. .	1,006	7th March 1923.	1 year
Do. .	(499) Tata Electro Chemicals, Ld.	Bauxite . .	P. L. .	693	16th April 1923.	Do.
Do. .	(500) Do. . .	Do. .	P. L. .	307	Do. .	Do.
Do. .	(501) Mr. Venkat Ramanna.	Do. . .	M. L. .	5	6th May 1923	30 years.
Do. .	(502) The Electro Chemicals Ld.	Do. . .	P. L. .	198	7th September 1923.	1 year.
Do. .	(503) Do. . .	Do. . .	P. L. .	58	15th September 1923.	Do.
Do. .	(504) Do. . .	Do. . .	P. L. .	24	Do.	Do.
Do. .	(505) Mr. Kashi Prosad Pande.	Do. . .	M. L .	1	20th April 1923.	30 years.
Do. .	(506) Mr. Venkat Ramanna.	Do. . .	M. L. .	21	28th July 1923.	Do.
Do. .	(507) Tata Electro Chemicals, Ld.	Do. . .	P. L. .	177	12th October 1923.	1 year.
Do. .	(508) Do. . .	Do. . .	P. L. .	147	Do. .	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore.	(509) Tata Electro Chemicals, Ld.	Bauxite	P. L.	423	20th November 1923.	1 year
Nagpur	(510) Rai Sahib Seth Naraindas.	Manganese	P. L.	72	2nd January 1923.	Do.
Do.	(511) Do.	Do.	P. L.	96	Do.	Do.
Do.	(512) The Central India Mining Co., Ld.	Do.	P. L.	26	1st February 1923.	Do
Do.	(513) Rai Sahib Ramkrishna Puri Gosai.	Do.	P. L.	663	16th March 1923.	Do
Do.	(514) Lala Jainarayan Mohonlal.	Do.	P. L.	30	6th January 1923.	Do
Do.	(515) Messrs. N. D. Zal and Brothers.	Do.	P. L.	104	2nd January 1923.	Do
Do.	(516) Mr. Shamji Narayanjee.	Do.	P. L.	51	11th May 1923	Do
Do.	(517) Do.	Do.	P. L.	97	Do.	Do
Do.	(518) Do.	Do.	M. L.	12	8th May 1923	5 years
Do.	(519) Seth Karnidass Chogmal.	Do.	P. L.	148	30th April 1923.	1 year
Do.	(520) Seth Meghraj Golcha.	Do.	P. L.	106	26th April 1923.	Do
Do.	(521) Lala Jainarayan Mohanlal.	Do.	P. L.	44	11th June 1923.	Do
Do.	(522) Messrs. Manwaah Turabli and Motilal.	Do.	P. L.	27	12th May 1923	Do.
Do.	(523) Do.	Do.	P. L.	91	27th June 1923.	Do
Do.	(524) Mr Ganpat Rao Laxman.	Do.	P. L.	122	7th September 1923.	Do
Do.	(575) Mr. Karsanji Vellanji.	Do.	P. L.	16	3rd August 1923.	Do
Do.	(526) Messrs. K R. Pade and Dube.	Do.	P. L.	115	11th September 1923.	Do
Do.	(527) Do.	Do.	P. L.	127	12th September 1923.	Do
Do.	(528) Do.	Do.	P. L.	107	11th September 1923.	Do
Do.	(529) Mr. Shriram Seth	Coal	P. L.	334	15th August 1923.	Do
Do.	(530) Messrs. Ramprasad and Laxminarayan	Manganese	P. L.	166	30th August 1923.	Do
Do.	(531) Do.	Do.	P. L.	177	28th July 1923.	Do.
Do.	(532) Rai Sahib Ramkrishna Puri.	Do.	P. L.	124	3rd August 1923.	Do

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(533) Rai Sahib Ramkrishnu Puri.	Manganese . .	P. L. .	7	3rd August 1923.	1 year
Do .	(534) Do. . .	Do. . .	P. L. .	35	7th September 1923.	Do.
Do. .	(535) Do. . .	Do. . .	P. L. .	45	Do. .	Do.
Do. .	(536) Messrs. Manwarali Turabali and Motilal.	Do. . .	P. L. .	28	15th August 1923.	Do.
Do. .	(537) Do. . .	Do. . .	P. L. .	37	21st September 1923.	Do.
Do. .	(538) Do. . .	Do. . .	P. L. .	30	7th September 1923.	Do.
Do. .	(539) Seth Bansidhar Ramniwas.	Do. . .	P. L. .	66	17th September 1923.	Do.
Do .	(540) Messrs. Rajnath and Dwarkanath.	Do. . .	P. L. .	72	8th August 1923.	Do.
Do .	(541) Mr. A. E. Tinch .	Do. . .	P. L. .	134	17th September 1923.	Do.
Do. .	(542) Do. . .	Do. . .	P. L. .	110	Do .	Do.
Do. .	(543) Do. . .	Do. . .	P. L. .	270	Do .	Do.
Do .	(544) Mr. S. Aminuddin	Do. . .	P. L. .	130	21st September 1923	Do.
Do .	(545) Rai Sahaib D. Laxmi Narayan.	Felspar . .	P. L. .	58	30th August 1923.	Do.
Do .	(546) Rai Sahib Ramkrishna Puri.	Manganese . .	P. L. .	77	24th October 1923.	Do.
Do. .	(547) Do. . .	Do. . .	P. L. .	116	Do. .	Do.
Do. .	(548) Do. . .	Do. . .	P. L. .	15	3rd December 1923.	Do.
Do. .	(549) Do. . .	Do. . .	P. L. .	32	Do. .	Do.
Do. .	(550) Do. . .	Do. . .	P. L. .	35	24th October 1923.	Do.
Do. .	(551) Pandit Rewashankar.	Do. . .	P. L. .	150	20th November 1923.	Do.
Do. .	(552) Messrs. Abdul Kadir, Abdul Ali and Bros.	Do. . .	P. L. .	250	17th November 1923.	Do.
Do. .	(553) The Indian Manganese Co.	Do. . .	P. L. .	90	10th December 1923.	Do.
Do. .	(554) Seth Karnidan Chhogmal.	Do. . .	P. L. .	105	24th October 1923.	Do.
Do. .	(554) Do. . .	Do. . .	P. L. .	2	14th December 1923.	Do.
Do. .	(556) Hon'ble Sir M. B. Dadabhoy.	Do. . .	P. L. .	75	26th October 1923.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*concld.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term
Nagpur	(557) Seth Bansidhar Ramniwas.	Manganese	P. L.	29	19th November 1923.	1 year
Do.	(558) Seth Meghraj Golcha.	Do.	P. L.	56	22nd October 1923.	Do
Do.	(559) Do	Do.	P. L.	127	Do.	Do
Do.	(560) Do.	Do.	P. L.	40	26th October 1923.	Do
Do.	(561) Messrs. Rajnath and Dwarkanath.	Do.	P. L.	8	Do.	Do
Do.	(562) Do.	Do.	P. L.	119	10th December 1923.	Do
Do.	(563) Seth Laxminarayan Hardeo	Do.	P. L.	44	3rd December 1923.	Do
Do.	(564) Do.	Do.	P. L.	130	27th November 1923.	Do
Do.	(565) Syed Hifzul Raqulb.	Do.	P. L.	90	26th October 1923.	Do
Do.	(566) Mr. M. A. Razaq	Do.	P. L.	867	19th November 1923.	Do
Do.	(567) Messrs. Ramkrishna Ramnath & Co.	Do.	P. L.	181	10th December 1923.	Do
Narsinghpur	(568) Mr. C. Stanley Harris.	Copper	M. L.	222	26th June 1923.	Do
Saugor	(569) Lala Pragnarayan.	Iron, iron pyrites, Sulphate of iron, Sulphur and Copper.	P. L.	1,554	11th September 1923.	Do.
Yeotmal	(570) Messrs. P. R. Patel & Co., Bombay.	Coal	P. L.	417	16th February 1923.	Do
Do.	(571) Do.	Do.	P. L.	580	Do.	Do

MADRAS.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term
Agency Division.	(572) Messrs. Best & Co.	Coal	P. L.	40,320	20th April 1923.	1 year.
Do.	(573) Do.	Do.	P. L.	5,280	11th April 1923.	Do
Anantapur	(574) A. Ghose, Esq	Barytes	M. L.	183·92	2nd October 1922.	30 years
Do.	(575) Janab Nabi Sahib Bahadur.	Mica	P. L.	112·05	6th April 1923.	1 year
Do.	(576) Mr. B. P. Sesha Reddi Garu.	Barytes	P. L.	2·26	Do.	Do.
Do.	(577) Do.	Steatite	P. L.	27·06	Do.	Do

P. L. = *Prospecting License*. M. L. = *Mining Lease*.

MADRAS—*contd.*

District.	GRANTEE.	Mineral.	Nature of grant.	Area in acres	Date of commencement.	Term.
Anantapur	(578) Superintendent, North Anantapur Gold Mines, Ltd.	Gold . . .	P. L. .	1,769 52	21st July 1923	1 year.
Do. .	(579) M. R. Ry. B. P. Sesha Reddi of Betham-cherla.	Steatite . .	M. L. .	27·96	1st November 1923.	30 years.
Bellary .	(580) A. Pichayya Nayudu.	Manganese . .	P. L. . (renewal)	601	15th October 1922.	1 year.
Do .	(581) A. Pichayya Nayudu and K. C. Narasimbachari.	Do. . .	P. L. . (renewal)	450	9th August 1922.	Do.
Do .	(582) K. Ramchandra, Esq. Bar.-at Law.	Clay . . .	M. L. .	52 78	29th June 1923.	5 years.
Do .	(583) Do. . .	Kaolin and other chemical earths.	P. L. .	200 1	Do.	1 year.
Do .	(584) M. R. Ry. Pitchiya Nayudu.	Manganese . .	M. L. .	1,557 20	22nd August 1923.	30 years.
Do	(585) M. R. Ry. Patel Patta Basappa.	Do. .	P. L. .	35 85	20th November 1923.	1 year.
Do	(586) M. R. Ry. Pitchiya Nayudu Garu . .	Do. . .	M. L.	601	18th December 1923	30 years.
Do .	(587) Mr. K. Abdul Hye	Do. . .	P. L. .	46·30	20th November 1923.	1 year
Cuddapah .	(588) A. Ghose, Esq. .	Barytes . .	P. L. .	127 58	6th June 1923	Do.
Do. .	(589) M. R. Ry. B. Chinnamola Reddi Garu.	Barytes and Asbestos.	P. L.	57 26	10th December 1923	Do.
Kurnool .	(590) M. R. Ry. R. A. Seshi Reddi Garu.	Barytes . .	P. L. .	2 07	29th June 1923	Do.
Do .	(591) Do. . .	Do. . .	P. L. .	9 5	Do.	Do.
Do .	(592) Do. . .	Do. . .	P. L. .	13 79	Do.	Do.
Do .	(593) Do. . .	Do. . .	M. L. .	3 21	Do.	30 years
Do .	(594) M. R. Ry. B. P. Sesha Reddi of Bethamcherla.	Manganese . .	P. L. .	46	7th August 1923	1 year.
Do. .	(595) Do. . .	Steatite . .	M. L. .	69 4	Do.	30 years
Malabar .	(596) Mr W. H. Perry .	Gold . . .	P. L. .	80	20th June 1923	1 year.
Nellore .	(597) K. C. Narasimachari.	Mica . . .	P. L. .	112.51	11th January 1923.	Do.
Do. .	(598) Mr. T. C. Dandayutham Pillai.	Do. . .	P. L. .	8.82	2nd December 1922.	Do.
Do. .	(599) Mr. R. Ry Kali Chetty Venka Reddi of Marupur.	Do. . .	P. L. .	13.38	5th October 1923.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

MADRAS—*concld.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore .	(600) M. R. Ry. S. V. Subba Reddi Garu.	Mica . . .	M. L. .	152.30	5th October 1923.	30 years
Nilgiris .	(601) Mr. A. H. Gaston	Do. . .	P. L .	56.57	14th June 1922.	1 year
Do. .	(602) Do. . .	Do. . .	P. L. .	62 84	12th February 1923.	Do.
Do. .	(603) Do. .	Do. . .	P. L. .	56.57	14th June 1923.	Do
Do. .	(604) Do. . .	Do. . .	P. L. .	303 90	18th December 1923.	Do
Salem .	(605) R. Alagappa Mudaliyar	Corundum . .	P L	148 08	17th February 1923.	Do
Do. .	(606) C Middleton	Magnesite .	P L	50 79	Do.	Do
Do. .	(607) Captain E K. Dickens	Emery .	P L	140	6th December 1923	Do

NORTH-WEST FRONTIER PROVINCE.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kohat .	(608) Edwin John Beer, Esq	All other minerals except oil i e, precious stone, gold and ores, particularly Stanlium and Sulphur	P L .	640	29th June 1923	1 year
Dera Ismail Khan.	(609) Messrs Graham & Co, Calcutta, through Mr G E. Stall	All minerals including mineral oil	E L. .	The area is covered by circle of 20 miles radius, the centre being Moghul Kot, Sherani country.	8th December 1923.	Do

PUNJAB.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jhelum .	(610) Jamada Fateh Ali Khan.	Coal . .	P L.	13	10th January 1923	1 year
Do.	(611) Do. . .	Do. . .	P L. .	15	Do.	Do.
Do. .	(612) L. Chuni Lal Kapur.	Do. . .	P. L. .	82	15th January 1923.	Do.
Do.	(613) R S. Thakur Das Ramjidas.	Do. . .	P. L. .	73.28	15th March 1923.	Do.
Do. .	(614) Do. . .	Do. . .	P. L. .	36.92	Do.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*
E. L.=Exploring License.

PUNJAB—*contd.*

District.	GRANTEE.	Mineral	Nature of grant	Area in acres	Date of commencement	Term
Jhelum .	(615) L. Ishar Das Kapur.	Coal . .	P L .	10	15th March 1923	1 year
Do .	(616) Messrs Whitehall Petroleum Corporation Ltd	Oil . .	P L .	934 40	30th April 1923	Do.
Do .	(617) Do. . .	Do . .	P L .	2,784	Do.	Do.
Do	(618) L. Churanjit Lal of Wahali.	Coal .	P L .	442 148	4th May 1923	Do.
Do	(619) Pandit Gian Chand	Do .	P L .	117.25	5th June 1923	Do.
Do	(620) Do . .	Do . .	M L	364	Do.	30 years
Do .	(621) L Chuni Lal Kapur	Do .	P L .	311	Do.	1 year
Do	(622) Do .	Do .	P L	180 44	1st September 1923	Do.
Do	(623) Punjab Coal Syndicate	Do	P L	1 444 5	22nd October 1923	Do.
Do .	(624) R G Tugwood .	Oil .	P L	3,200	12th November 1923	Do.

P L.=*Prospecting License* M L =*Mining Lease*

SUMMARY.

PROVINCE	Exploring License	Prospecting License	Mining Lease	Total of each Province
Assam		12	1	13
Bengal		7		7
Bihar and Orissa		2	20	22
Bombay	.	2	1	3
Burma	.	243	39	282
Central Provinces	..	204	40	244
Madras	..	28	8	36
North West Frontier Province . . .	1	1	.	2
Punjab	..	14	1	15
Total of each kind and grand total for 1923 .	1	513	110	624
TOTAL FOR 1922 .	..	562	110	672

CLASSIFICATION OF LICENSES AND LEASES.

TABLE 39.—*Prospecting Licenses and Mining Leases granted in Assam during the year 1923.*

District.	1923. No.	1923. Area in acres.	1923. Mineral.
Prospecting Licenses.			
Cachar	2	2,945·60	Mineral oil.
Garo Hills	7	13,440	Coal
Lakhimpur	3	12,608	Mineral oil
TOTAL	12	..	
Mining Lease.			
Lakhimpur	1	160	Oil
TOTAL	1	..	

TABLE 40.—*Prospecting Licenses granted in Bengal during 1923.*

DISTRICT.	1923. No.	1923. Area in acres.	1923. Mineral
Prospecting License.			
Chittagong Hill Tracts	7	73,370·24	Mineral oil.

TABLE 41.—*Prospecting Licenses and Mining Leases granted in Bihar and Orissa during 1923.*

DISTRICT.	1923. No.	1923. Area in acres.	1923. Mineral.
Prospecting Licenses.			
Sambalpur	1	114·28	Mica.
Do.	1	95·2	All minerals
TOTAL	2	..	
Mining Leases.			
Hazaribagh	2	956	Mica.
Sambalpur	1	57·86	Do.
Santal Parganas	14	42 8	Coal.
Singhbhum	1	153·65	Manganese.
Do.	2	1,130	Chromite
TOTAL	20	..	

TABLE 42.—*Prospecting Licenses and Mining Leases granted in Bombay during 1923.*

DISTRICT.	1923. No.	1923. Area in acres.	1923. Mineral.
Prospecting Licenses.			
Sukkur	2	32,755·38	Mineral oil.
Mining Lease.			
Belgaum	1	320	Manganese ore

TABLE 43.—*Prospecting Licenses and Mining Leases granted in Burma during 1923.*

District.	1923.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Akyab	4	18,980	Mineral oil.
Amherst	3	16,000	Do.
Do.	5	3,070	All minerals (except oil).
Do.	2	35,622·40	Oil shale.
Do.	1	15,520	Mineral oil and oil shale.
Bhamo	1	3,328	All minerals (except mineral oil and jade).
Henzada	1	640	Mineral oil.
Do.	1	4,640	Coal.
Katha	4	2,202	All minerals (except oil).
Lower Chindwin	8	45,895·60	Mineral oil.
Magwe	33	50,186·30	Do.
Mandalay	1	2,560	All minerals (except oil).
Mergui	8	7,260·16	Tin and allied minerals.
Do.	12	12,822·26	Tin.
Do.	1	640	Cassiterite and gold.
Do.	1	1,120	Wolfram, tin and allied minerals.
Do.	7	12,835·84	All minerals (except oil).
Do.	2	6,277·12	Mineral oil and coal.
Do.	1	2,201·80	Coal.
Minbu	17	24,977·65	Mineral oil.
Do.	2	9,920	All minerals including mineral oil.
Do.	1	220	Coal and mineral oil.
Myingyan	7	22,138·40	Mineral oil.
Northern Shan States	4	1,570	Iron.
Do.	2	5,120	All minerals (except oil).
Pakokku	15	26,631·2	Mineral oil.
Prome	7	19,704·32	Do.
Do.	2	7,001·60	All minerals except amber and jadeite.
Shwebo	6	47,635·20	Mineral oil.
Do.	1	1,920	All minerals (except oil).
Do.	1	1,920	Coal.
Southern Shan States	8	25,012·97	All minerals (except oil).
Do.	1	40	Lead.
Do.	2	6,080	Gold, copper, etc.
Tavoy	10	4,302·60	Tin and wolfram.
Do.	6	3,548·10	All minerals except oil.
Do.	5	2,829	Tin and allied minerals
Do.	3	5,120	Tin and other minerals.
Do.	2	166·5	Tin.
Carried over	198	..	

TABLE 43.—*Prospecting Licenses and Mining Leases granted in Burma during 1923*—contd.

District.	1923.		
	No.	Area in acres.	Mineral.

Prospecting Licenses—*contd.*

District.	No.	Area in acres.	Mineral.
Brought forward	198		
Tharrawaddy	1	640	Mineral oil.
Thaton	1	505·6	Tin.
Thayetmyo	31	127,279·12	Mineral oil.
Upper Chindwin	6	25,894·40	Do.
Do.	3	12,672	Mineral oil and coal.
Do.	3	14,105·6	Coal.
TOTAL	243	..	

Mining Leases.

District.	No.	Area in acres.	Mineral.
Amherst	3	1,881·60	Tin Ore.
Bhamo	1	3,232·62	All minerals (except oil and precious stones).
Henzada	1	236·8	Iron pyrite.
Katha	1	1,820	Graphite.
Magwe	1	640	Mineral oil.
Mergui	11	5,275·56	Tin.
Do.	2	5,416·36	All minerals (except oil).
Do.	2	931·84	Tin and allied minerals.
Do.	1	1,418·24	Tin and Wolfram.
Minbu	3	1,828	Mineral oil.
Northern Shan States	2	640	Iron.
Prome	1	409·60	Mineral oil.
Tavoy	4	1,762·90	Tin and Wolfram.
Do.	2	544·41	All minerals except oil.
Do.	1	817·53	Tin and allied minerals.
Do.	1	657	Wolfram, tin and allied minerals.
Thayetmyo	2	640	Mineral oil.
TOTAL	39	..	

TABLE 44.—*Prospecting Licenses and Mining Leases granted in the Central Provinces during 1923.*

DISTRICT.	1923. No.	1923. Area in acres.	1923. Mineral.
Prospecting Licenses.			
Balaghat	32	2,823	Manganese.
Do.	2	82	Mica.
Betul	15	5,616	Coal.
Do.	1	92	Iron and ferric oxide.
Bhāndara	16	1,862	Manganese.
Bilaspur	3	16,408	Coal.
Chanda	6	5,022	Do.
Chhindwara	31	2,444	Manganese.
Do.	15	2,688	Coal.
Hoshangabad	6	1,557	Do.
Jubbulpore	12	3,394	Bauxite.
Do.	4	1,507	Coal.
Do.	1	1,906	Manganese, copper, gold and silver.
Nagpur	55	6,246	Manganese.
Do.	1	334	Coal.
Do.	1	58	Felspar.
Saugor	1	1,554	Iron, iron pyrites, sulphate of iron, sulphur and copper.
Yeotmal	2	997	Coal.
TOTAL	204	..	
Mining Leases.			
Balaghat	14	918	Manganese.
Bhandara	2	39	Do.
Chanda	1	278	Coal.
Chhindwara	15	3,323	Do.
Do.	2	39	Manganese.
Jubbulpore	3	27	Bauxite.
Do.	1	36	Coal.
Nagpur	1	12	Manganese.
Narsinghpur	1	222	Copper.
TOTAL	40	..	

TABLE 45.—*Prospecting Licenses and Mining Leases granted in Madras during 1923.*

District.	1923. No.	1923. Area in acres.	1923. Mineral.
Prospecting Licenses.			
Agency Division	2	45,600	Coal.
Anantapur	1	112·05	Mica.
Do.	1	2·26	Barytes.
Do.	1	27·96	Steatite.
Do.	1	1,769·52	Gold.
Bellary	4	1,133·15	Manganese.
Do.	1	200·1	Kaolin and other chemical earths.
Cuddapah	1	127·58	Barytes.
Do.	1	57·26	Barytes and asbestos.
Kurnool	3	25·36	Barytes.
Do.	1	46	Manganese.
Malabar	1	80	Gold.
Nellore	3	134·71	Mica.
Nilgiris	4	479·88	Do.
Salem	1	148·08	Corundum
Do.	1	50·79	Magnesite.
Do.	1	140	Emery.
TOTAL	28	..	
Mining Leases.			
Anantapur	1	183·92	Barytes.
Do.	1	27·96	Steatite.
Bellary	1	52·78	Clay.
Do.	2	2,158·20	Manganese.
Kurnool	1	3·21	Barytes.
Do.	1	69·4	Steatite.
Nellore	1	152·30	Mica.
TOTAL	8	..	

TABLE 46.—*Prospecting and Exploring Licenses granted in North-West Frontier Province during 1923.*

DISTRICT.	1923.		
	No.	Area in acres.	Mineral.
Prospecting License.			
Kohat	1	640	All other minerals except oil, *i.e.*, precious stone gold and ores, particularly stanlium and sulphur.
Exploring License.			
Dera Ismail Khan . . .	1	The area is covered by circle of 20 miles radius, the centre being Moghal kot Sherani country.	All Minerals including mineral oil.

TABLE 47.—*Prospecting Licenses and Mining Leases granted in the Punjab during 1923.*

DISTRICT.	1923.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Jhelum	11	2,734	Coal.
Do.	3	6,918	Oil.
TOTAL .	14	..	
Mining Lease.			
Jhelum	1	364	Coal.

THE SODA-BEARING ROCKS OF KISHENGARH, RAJPUTANA, BY A. M. HERON, D.SC., F.G.S., *Officiating Superintendent, Geological Survey of India.* (With Plates 2 to 12.).

INTRODUCTION.

THE interesting elæolite and sodalite bearing rocks of Kishengarh were first known from specimens sent to the Geological Survey of India by Rao Bahadur Syam Sunder Lall, C.I.E., Diwan of Kishengarh State, and a short note on them was contributed by the late Mr. E. Vredenburg.[1] Mr. Vredenburg draws attention to the colour change of the elæolite-sodalite-pegmatite as follows :—

"Moreover some of the sodalite exhibits an extraordinary phenomenon hitherto unrecorded in any mineral. While some of the specimens are of a bright blue colour similar to that of the mineral from many other localities, others appear under ordinary conditions transparent and colourless. But some of these colourless fragments when kept in the dark for a fortnight or three weeks assume a pink colour which disappears rapidly on exposure to bright daylight, and almost instantaneously in direct sunshine.

The phenomenon is particularly brilliant when the rock is first broken in the field, and the large blocks of elæolite (some of which are over a yard wide) appear, on fracture, as if suffused with blood. The colour seems to re-appear more completely in some specimens than in others, for while the disappearance of the colour is very rapid, its re-appearance, which constitutes the most remarkable feature of the change, is very slow. The precise nature and cause of this peculiar phenomenon are at present unknown The following analysis gives the percentage composition of a specimen of the blue sodalite :—

Loss on ignition	0·82
SiO_2 (Silica)	38·055
Al_2O_3 (Alumina)	31·30
Fe_2O_3 (Iron sesquioxide)	trace.
CaO (Lime)	0·001
Na_2O (Soda)	24·77
SO_3 (Sulphur trioxide)	trace.
Cl (Chlorine)	7·18
Less oxygen equivalent of chlorine	1·618
TOTAL	100·508

Specific gravity . . . . 2·27

[1] *Rec., Geol. Surv. Ind.,* XXXI, p. 43 (1904).

The other variety exhibiting the curious change of colour has been found so intimately intergrown with elæolite that it is not possible to obtain a complete analysis. Partial analysis indicates, however, almost exactly the same percentage as for the blue variety.

The elæolite-bearing rocks are surrounded by scapolite-gneisses and all the syenites contain scapolite associated with the elæolite and sodalite. The elæolite-sodalite-pegmatite contains large crystals of ægirine, sphene and lime-iron-garnet."

In the annual report for 1903-4, Sir Thomas Holland draws attention to the same peculiarity :[1]

"When freshly broken, the patches of sodalite are carmine in colour and the fresh rock-face gives the appearance of being splashed with blood, but in daylight the colour rapidly, and in direct sunlight almost suddenly, disappears. Many of the specimens when kept in the dark for a few months recover their carmine colour, losing it again on exposure either to daylight or to electric light. The sodalite does not, so far as we can find, differ in chemical composition from the ordinary varieties of the mineral, and neither the loss nor the recovery of colour is affected by the humidity of the atmosphere."

The discovery of cancrinite, by Babu Baidyanath Saha, is also recorded from the north-east extension of the main syenite mass. During the field study and collection of specimens of the syenites I was accompanied by Dr. Murray Stuart, whose co-operation I gratefully acknowledge.

General Geology.

Within an area 10 miles long by 2 miles wide, lying north-east from Kishengarh City (26° 31' : 74° 55'), are one large and nine small masses of syenite in the form of sill-like intrusions in the Aravalli schists, markedly elongated in the general direction of the strike of these rocks, the syenites themselves being strongly banded and foliated in the same direction.

The rocks of the Aravalli System here consist chiefly of micaceous thin-bedded quartzites, quartz-mica-schists and mica-sillimanite-schists, all highly metamorphosed and intruded by amphibolite,[2] granite and pegmatite. A mile east of Kishengarh Railway Station the road crosses an anticline of impure vitreous quartzites, inter-

[1] *Rec., Geol. Surv. Ind.,* XXXII, p. 158 (1905).

[2] "Epidiorite" according to the recommendations of the Joint Committee on Petrographic Nomenclature.

bedded with which is a bed of graphitic mica-schist, about 4 feet thick, from which a mineral paint has been made and used on railway rolling stock. A mile or two still further to the south-east vein granites and pegmatites are so abundant in the Aravallis that the result is a banded rock or injection gneiss ("migmatite" of Sederholm[1]) in which ramifying and interfoliating veins penetrate the rock to such a degree that over large areas there is not a square foot free from them.

Besides these, numerous lenticular bosses of intrusive granite occur, some of large size, but those in the immediate vicinity of the syenites are insignificant. These granites are often foliated and in general resemble in their minerals the vein granites. The final result, especially where pressure has acted upon and rolled out the vein granite, is a banded rock which may be termed a "gneiss," interspersed with, and often merging imperceptibly into, areas of "gneissic granite" or "granitic gneiss". The complex is highly puzzling at first sight, but some of its obscurities are resolved by close study.

The evidence available goes to prove that the soda-syenites and their associated pegmatites were intruded previous to the deposition of the overlying Delhi System, the base of which lies a mile to the west of Kishengarh City As the syenites are, so far as was seen, not penetrated by any of the very numerous granites, pegmatites and amphibolites (epidiorites) which are in such force in the surrounding rocks, it is at least possible that their absence may be due to the syenites being later in their period of intrusion than any of the others. Above, *i.e.*, to the west of the Delhi-Aravalli unconformity, no exposures of syenite are found, and, as the accompanying geological map shows, the line of the unconformity appears to cut across the strike of the syenite sills and the Aravalli schists at a low angle.

The basal beds of the Delhi system, to a thickness of more than 2,000 feet, are exposed in the high ridge which overlooks the plain of Aravalli rocks, and consists of felspathic conglomerates dipping away from the Aravallis at angles of 80° and higher. From Kishengarh City the unconformity has been followed to the south-west as far as my survey has proceeded, for nearly 80 miles; 6 miles to the north-east the ridge is interrupted by alluvium but is met

[1] "On Regional Granitisation (or Anatexis)," *Congrès Géologique International*, 12th session (1913).

with again along its strike-continuation, in the great mass of conglomeratic quartzites at Khakirdi, on the southern shore of the Sambhar Lake, and again to the north of the Lake in the conglomerates of Marot in Jodhpur. All along, wherever exposed, the unconformity is accompanied by arkose and conglomeratic beds, but their thickness is very variable from point to point, partly owing to original inequalities of accumulation, and partly due to repetition in some places and cutting-out in others, by multiple thrust-faults and slides along the unconformity.

In connection with the faulting may be noted the puzzling discovery of five or six large fragments of syenite along the base of a ridge parallel to, and at a distance of 4 miles to the west of, the range which marks the unconformity. Ruling out human transportation, which is quite unlikely, these fragments may have come either from a body of syenite close at hand but concealed below alluvium, or may have weathered, as boulders, from an irregular conglomerate which appears in the ridge and is derived from the disintegration of Aravalli rocks. In either case, taking into account the fact that the facies of the rocks of this ridge suggests that they are at or near the base of the Delhi System, it is possible that the lowest beds of the Delhis, with a section of the Aravallis, are here repeated by a strike-fault; unfortunately alluvium is so extensive and so deep that other field evidence cannot be obtained.

In the Kishengarh neighbourhood the Delhis above the basal beds are almost entirely concealed, but further to the south-west, towards Ajmer and Beawar, good sections are obtained, which show them to consist of thick quartzites, mica-schists and impure limestones folded synclinally into the Aravallis, with a great development of intrusive pegmatite, granite and amphibolite (epidiorite). The rock types are more definite in the Delhis than in the Aravallis, and in the former the various congeries of quartzites, mica-rocks and limestones, as the case may be, are thicker and more uniform within each set, whereas the Aravallis have a certain indefiniteness of character and such quartzites and calcareous bands as occur in them are thin and intercalated with the predominant rock-type—mica-schist.

The scenery reflects the geological structure. In the Delhis we have high continuous ridges of quartzites and, to a less extent, of limestone, alternating with valleys eroded along the softer rocks, while the Aravallis form a monotonous "gneissic plain."

The earlier pre-Delhi granite and pegmatite intrusive into the Aravallis, are distinct and distinguishable from the later post-Delhi granite and pegmatite.

Description of the Syenites.

The ten masses of syenite are on different horizons, and the largest has an irregular margin, owing to the low and variable dip of the rocks enclosing it, to which it is roughly parallel but to a certain extent transgressive. The four outcrops farthest to the north-east are isolated in, and separated from each other by, alluvium and the real form of the intrusions to which they belong is accordingly unknown.

In texture the syenite is very variable but may be divided into three mutually merging varieties:—a granitoid type in which the minerals are evenly distributed with no orientation in any particular direction, a foliated type in which the small patches of the different minerals are elongated in parallel planes, and a banded type in which layers of rock poor in dark ferro-magnesian minerals, an inch or two wide, alternate with basic bands of about the same thickness, consisting almost entirely of ferro-magnesians. In the first the clusters of amphibole are compact (glomero-porphyritic texture of Judd)[1], but in the two other varieties are markedly crushed and broken up, as if by motion in a semi-consolidated magma (glomero-plasmatic texture of Lœwinson-Lessing).[2]

Both foliation and banding follow the foliation of the enclosing Aravalli rocks, the largest mass is very strongly banded or foliated over most of its outcrop, and its foliation dips are at low angles, 20°—40° to north-west and west-north-west, and are notably regular, taken as a whole, though in detail often much corrugated.

In the field the grain of the rock is that of a somewhat coarse, non-porphyritic granite, but as explained below, the grain under the microscope, is much finer than is macroscopically apparent, for what appear to be mineral individuals are in reality aggregates of like minerals.

[1] *Quart. Journ. Geol. Soc.*, XLII, (1886), p. 71.
[2] "Geologische Skizze der Besitzung Jushno-Saosersk und des Berges Deneshkin Kamen in nördl. Ural," (1900), p. 208.

In hand specimens, or more clearly on weathered surfaces, it appears to have three mineral constituents:—(*a*) grey, with a greenish tinge and greasy lustre, which weathers more readily than the other two, thus giving rise to recesses and producing the conspicuous pitted surface characteristic of the syenite, (*b*) in about equal amount to (*a*), an aggregate of pure white granular crystals with pearly lustre, projecting in relief on weathering and sometimes showing simple twinning to the naked eye, (*c*) a greenish black mineral, in less amount than either (*a*) or (*b*), weathering more readily than (*b*) and less readily than (*a*), seen in hand specimens to be made up of interfelted elongated crystals showing a distinct cleavage. (*a*) The greyish constituent is under the microscope seen to be clusters of nepheline grains with a certain intermixture of felspars, (*b*) is essentially an aggregate of orthoclase and microcline (probably soda-microcline) with some albite, and (*c*) is mainly amphibole with sphene and apatite. Biotite and garnet are also present in some modifications.

There is thus visible in the field an almost complete differentiation of the magma into three portions, consisting essentially of felspathoids, felspars and ferro-magnesians. Doubtless had crystallization taken place under static conditions these patches would have produced large crystals, but owing to slight movement in the magma during consolidation, crystallization round certain centres has been interfered with, and a somewhat granulitic rock results of aggregates composed more or less of one mineral. Holland has drawn attention to the prevalence of this tendency (glomero-plasmatic texture of Loewinson-Lessing) in the charnockites and the Sivamalai syenites.[1] Further movement under pressure produces the foliated varieties [2] wherein these aggregates of crystallization are drawn out into lenticles and sheets.

In the syenite, nepheline occurs in two generations, the older of rounded phenocrysts, of small size, and the younger of small allotriomorphic grains scattered through the felspathic groundmass.

As well as phenocrysts of nepheline, there are in the granitoid variety less numerous phenocrysts of microcline which do not show

[1] *Mem., Geol. Surv. Ind.*, XXVIII, pp. 152, 241, (1900); *Mem., Geol. Surv. Ind.*, XXX, p. 195, (1901).

[2] *Mem., Geol. Surv. Ind.*, XXVIII, p. 221, (1900); Bonney and McMahon, "Crystalline rocks of the Lizard district," *Quart. Journ. Geol. Soc.*, XLVII, p. 478, (1891).

crystal outlines. The finer groundmass consists largely of felspar, which under the microscope appears as an equidimensional mosaic of clear grains. These are clear and unweathered, and are mostly untwinned and probably orthoclase, but microcline, albite and oligoclase also occur in subordinate amount. The plagioclases were identified by the method of Michel-Lévy—of extinction angles measured from the trace of the albite lamellation. Perthitic intergrowths of microcline with orthoclase are frequent. Among the felspars cancrinite and calcite are present interstitially in small amounts and are certainly primary constituents. The Becke method of gelatinising with hydrofluoric acid and staining with malachite green was used in an attempt to identify quartz, which appears to be absent.

The texture of this groundmass is the same as the "mosaic texture" illustrated by Holmes[1] and Weinschenk and Johannsen.[2]

The ferro-magnesian minerals are abundant and occur in irregular clusters consisting of both biotite, with small included zircons, and the characteristic amphibole of the rock, with sphene and apatite in considerable amount and in some slides corroded garnets, brown (melanite) and pale pink (almandine). The amphibole is in large ragged plates and may be classified as a hornblende with an abnormally high extinction angle, 36° as a maximum, and pleochroic from deep blue-green to greyish-yellow.

The composition of the foliated variety does not differ materially from the above, except that the minerals have a distinct banded or lenticular arrangement and are, in some slides, but not always, seen to be crushed. The ferro magnesian minerals make up a larger proportion of this than they do in the granitoid variety and are still more abundant, relatively, in the banded type.

In the latter the phenocrysts of nepheline are sometimes irregular and broken, and surrounded by fine detached particles. The felspathic groundmass may have "mortar" texture[3], or may be mylonised and granulitic in part.

[1] Holmes, "Petrographic Methods and Calculations," pl. 4, fig. 6.

[2] Weinschenk and Johannsen, "Fundamental Principles of Petrology," pl. 5, fig., pl. 6, fig. 1.

[3] Weinschenk and Johannsen op. cit. pl. V, fig. 4.

Analyses of Indian Soda-syenites.

	Normal syenite, Kishengarh. (B. C Gupta).	Dark banded syenite, Kishengarh. (B. C. Gupta.)	Vizagapatam syenite. (T. L. Walker).	Sivamalai syenite. (T. L. Walker).	Miaskite, Urals[1]. (M. Bourdakow).
SiO_2 .	55·32	54·52	52·60	55·68	56·26
Al_2O_3 .	23·78	24·32	26·00	23·81	23·59
Fe_2O_3 .	4·73	6·02	Fe_2O_3 ·91 FeO 2·21	4·84	Fe_2O_3 ·85 FeO 2·61
MgO .	1·07	·43	·51	·65	·27
CaO .	1·18	1·71	1·80	1·69	·54
Na_2O .	8·46	10·62	7·06	9·23	7·77
K_2O .	4·50	1·60	6·94	5·16	5·72
H_2O .	.	..	·61	·34	·37
Cl .	·64	·99	..	..	
	99·68	100·81	CO_2 ·55	Graphite ·58	CO_2 1·37
Less O	·14	·22	..	..	TiO_2 ·47 MnO ·09
	99·54	100·59	99·88	101·98	99·91

Felspathoid-bearing rocks have hitherto been recorded from four other localities in India—Sivamalai, elæolite-syenite described by Sir Thomas Holland[2]; Vizagapatam, a miaskite described by T. L. Walker[3]; Mount Girnar, Kathiawar, a monchiquite described by J. W. Evans[4]; and from Sarnu, Jodhpur, a tinguaite described by Sir Thomas Holland[5].

All of these are too distant from Kishengarh for any magmatic relationship to be likely. The Kishengarh rock appears to correspond more or less with miaskite, grading towards shonkinite in the dark portions.

The Associated Pegmatites.

Traversing the various exposures are one or two veins of micro-syenite of small size and differing from the normal rock only in texture but not in composition, and also a few large veins of coarse pegmatite of great interest from the minerals they carry. The commonest

[1] Karpinsky, Guide. VII Cong. Geol. Inter., V, p. 22, (1897).
[2] *Mem., Geol. Surv. Ind.*, XXX, pp. 169—217, (1901).
[3] *Gen. Rep., Geol. Surv. Ind.*, 1902—3, p. 25; *Rec., Geol. Surv. Ind.*, XXXVI, pp. 19—22, (1907).
[4] *Q. J. G. S.*, LVII, pp. 38—54, (1901).
[5] *Mem., Geol. Surv. Ind.*, XXXV, p. 92, (1902).

are composed of the amphibole of the syenite but in large crystals and aggregates, with quartz, microcline and other felspars. These occur in force beyond the margin of the main syenite body, in the low scarp of quartzites to the south-east of it, and are in fact more numerous outside the syenite than within its limits. Another common variety carries large individuals of grey elæolite sometimes more than a foot in diameter with interstitial finely granular material consisting of sodalite and of an intergrowth of elæolite and sodalite, occasionally accompanied by cancrinite. The sodalite is intensely blue or colourless and is otherwise distinguishable from the elæolite by its greater transparency, saccharoidal granularity and by its brighter lustre as compared with the characteristic greasy aspect of the latter. The remarkable fading of the carmine tint of the freshly broken rock takes place in this type of pegmatite when the sodalite is colourless, but by no means all the colourless sodalite exhibits this property. The quartz-felspar-amphibole and elæolite-sodalite pegmatites occur most commonly and in the largest veins; the others are in small and scarce bodies. Perhaps the most striking is the bizarre rock consisting of pure white felspar veined and marbled with deep blue sodalite, bright yellow cancrinite and shining black biotite. The felspar is microcline perthitically intergrown with orthoclase and also the two species in granular aggregates. The sodalite and cancrinite are also granular, in veins containing both, or of sodalite alone, in the former case the sodalite being colourless, in the latter blue Near Mandaoria in particular as well as at other points within the syenite masses, are veins of a pegmatite in which cancrinite is the principal mineral, in granular masses and large crystals up to a foot in length, with sodalite and biotite. The cancrinite appears to have crystallised before the sodalite, which is in veins and interspaces between the cancrinite crystals.

Another form of pegmatite is characterised by large idiomorphic pale pink garnets in cancrinite and felspar (albite and oligoclase in part) with biotite, apatite, sphene and sometimes calcite. The felspars are somewhat cloudy, show cleavage clearly, and have irregular and interlocking margins—"sutured" texture[1] with much interstitial fine material. In the coarse granitoid rock adjoining this pegmatite the felspars show granophyric structure. This pegma-

[1] Weinschenk and Johannsen, op. cit., pl. V, figs. 2 and 3.

tite also carries molybdenite as a rare accessory, but I may parenthetically remark, it is not in economic quantity. Brown garnet (melanite), very similar to that of the syenite of Girnar, Kathiawar, is also found in pegmatite as well as in the normal rock, but in the pegmatite it occurs as small veins, unlike the pink garnet, which gives well formed crystals.

Pyroxene has only very doubtfully been recognized in the syenite, in small green grains, and if really present, is quite an unimportant constituent. There is however, one occurrence south of Mandaoria, where large crystals of ægirine-augite are enclosed in an elæolite-sodalite-microcline pegmatite and also, with amphibole, in the immediately adjoining syenite.

In the Boharu hill, the outcrop farthest to the north-east, which is composed of the normal unfoliated or granitoid form of syenite, the associated pegmatites consist of elæolite, sodalite and a white felspar, which on microscopical examination proves to be microcline, perthitically intergrown with oligoclase.

The Tilornia body is aberrant in that felspathoids are absent, quartz is present in small veins, and the principal ferro-magnesian appears, but doubtfully, to be a green pyroxene in ragged aggregates, with sphene and iron ores. The felspars are microcline and orthoclase. In the associated pegmatites however, amphibole is largely developed, both in large, stout crystals and fibrous bundles. This amphibole is the same as that of the syenite in the other intrusions.

Contact Rocks.

The rocks enclosing the syenites have been briefly alluded to. Limestones are by no means common in the Aravallis, but an interesting and handsome calcareous contact rock has been found at several places near Mandaoria, just outside the eastern margin of the main syenite mass, not in a definite bed, but in scattered and isolated blocks without visible arrangement. It is a white or pale grey saccharoidal rock, fine-grained, with scattered and ill-defined blotches of rose-pink and pinkish-yellow, in which a fibrous structure is apparent. The white portion of the rock is seen under the microscope to be made up of calcite and cancrinite in about equal amount, the latter in parallel blades and fibres or in irregular plates and elongated scales, which are in approximate optical continuity and extinguish together over the field of view, with the calcite scattered through it, and also in lenticles. In another variety a mosaic of secondary felspars with sutured margins encloses linearly-arranged scales of calcite and cancrinite, thus indicating the general fibrous nature of the rock. The pink portions of the rock consist of dendritic clusters and radiating wisps of elongated crystals of a pink, feebly pleochroic zoisite containing manganese, which with crossed nicols gives anomalous yellow and indigo interference colours, (see p. 196).

The scapolite gneisses recorded by Vredenburg have not been recognised, and two of his specimens thus designated prove on examination to be melanocratic varieties of the syenite; when he visited the locality cancrinite had not been recorded by Babu Baidyanath Saha and it is probable that cancrinite was mistaken for scapolite, as the two minerals are quite indistinguishable in micro-sections, unless basal sections, are available showing the intersections of the prismatic cleavages, in cancrinite meeting at 60°. in scapolite at 90°.

Notes on the constituent minerals.

Elæolite.

I use the name elæolite for the dominant felspathoid of these rocks, according to the customary usage of that term for the massive variety of nepheline found in plutonic rocks. In this case, so clear and unaltered is the mineral, that as far as the petrological characteristics of the mineral itself are concerned, it might with equal propriety be called nepheline.

Both in the syenite and the associated pegmatites it weathers with a thin soft yellowish-grey crust resembling the chalky crust on flint, but this decomposition is superficial, and immediately underneath the mineral is found to be quite fresh. When in small aggregates, as in the body of the syenite surrounded by felspars and ferro-magnesians of superior resistant powers, it weathers in recesses giving rise to the highly characteristic pitted aspect of the rock; but in the large masses in the pegmatites the chalk-like crust is readily removed by wind and rain and the peculiar greasy lustre and grey colour of the mineral are made apparent.

In the typical syenite the elæolite appears to be of two generations. The older consists of rather rounded individuals, sometimes showing an approximation to hexagonal outlines, perfectly clear, colourless and remarkably fresh, but with minute colourless or pale green platy inclusions, arranged linearly in parallel with the direction of extinction in longitudinal sections, and in transverse sections in lines intersecting at 60°, *i.e.*, parallel with the prism faces of the crystals. In some cases the inclusions themselves have straight extinctions; they appear to be minute laths of acid plagioclase and biotite, and the green ones may be amphibole or pyroxene, but they are not determinable with certainty. Only exceptionally does the elæolite show prismatic cleavage, in basal sections intersecting at 60° The later generation is in smaller grains without inclusions, and is also clear and colourless. Usually it forms a fine-grained mosaic with the felspars, from which it is sometimes difficult to distinguish.

The mineral is usually distinguishable by its low double refraction and by the uniaxial figure given by suitable basal sections, but gelatinization with hydrochloric acid and staining with malachite green or fuchsine, performed either on microscope sections or on polished blocks, displays the proportion which the elæolite bears to the other components and also shows its tendency to segregate in patches, leaving the intervening areas o cupied mainly by felspars, but with small amounts of it with them.

In the basic bands and lenticles, where ferro-magnesian minerals predominate, elæolite is not found. In the pegmatites elæolite occurs in intimate association with sodalite, the typical arrangement being of large individuals of elæolite often several inches in diameter, but without crystal outlines, separated by interstitial matter consisting of granular elæolite and sodalite in a form of intergrowth. Cancrinite and biotite are frequently found with this type.

An analysis of a portion of one of those large individuals gives:—

	Kishengarh[1]. (B. C. Gupta). Per cent.	Sivamalai[2]. (T. H. Holland). Per cent.
SiO_2	39·04	43·35
Al_2O_3	35·36	34·32
Fe_2O_3	trace	1·02
MgO	0·40	..
CaO	*Nil.*	0·82
Na_2O	17·998	14·62
K_2O	4·33	5·52
H_2O	..	..
Cl	3·91 Loss on ignition.	0·75
	101·038	
Less O.	0·880	
TOTAL	100·158	100·40

Performed in the Laboratory of the Geological Survey of India.

I have attached for comparison the analysis of the Sivamalai elæolite given by Holland[2]. The percentage of chlorine. 3·91, shows that the Kishengarh mineral is considerably contaminated with sodalite.

Felspars.

Microcline, orthoclase, albite and oligoclase are present. Microcline, like the elæolite, occurs in two generations in the syenite, neither being in idiomorphic crystals. The earlier and larger individuals are about the same size as those of the earlier elæolite, and the smaller and later are in small grains, forming with the other felspars the bulk of the rock. Twinning according to the pericline mode is often on so fine a scale as to suggest that the felspar may be soda-microcline (anorthoclase). The practical impossibility of isolating a product unmixed with other felspars has prevented an analysis being made. In the larger individuals especially it is microperthitically intergrown with clear orthoclase. Microcline does not occur in the elæolite-sodalite type of pegmatite, but is common in the amphibole and quartz-bearing type and also occurs in the striking rock composed of blue sodalite, yellow cancrinite, and white microcline. In the Boharu mass there are prominent veins of elæolite-microcline pegmatite in which the microcline is micrographically intergrown with quartz and microperthitically with oligoclase.

Orthoclase is in subordinate amount to microcline, usually in clear and quite unweathered grains, untwinned, but showing cleavages intersecting at approximately right angles. Plagioclase, (chiefly albite and oligoclase) is an occasional constituent of the syenite, and is confined to the fine-grained groundmass.

Amphibole.

In the syenite amphibole occurs both as large crystals, usually ragged and not showing good crystal outlines, but with well developed prismatic cleavages, and as irregular aggregates of small individuals, associated with abundant sphene and apatite. In the pegmatites it forms veins and masses, often very coarsely crystalline, and fibrous aggregates.

Its pleochroism colours are: X=greyish-yellow, Y=blue-green and Z=blue-green; it is positive and dark-slow The extinction angle, $Z \wedge c$, is 36° as a maximum of all observed sections, a common maximum being 24° to 27°. Hastingsite has extinction angles of 24° to 30°, katoporite (cataphorite) 31° to 58°, and basaltic hornblende has sometimes an extinction angle as high as 37°. The pleochroism colours agree with those of hastingsite[1], X=yellow-green, Y=deep blue-green, Z=deep blue-green; and with the basaltic hornblende from Beverley[2], X=greenish-yellow, Y=olive-green, Z=blue-green.

A detailed analysis of this amphibole (registered number 30-287) by W. A. K. Christie gives the following composition:—

		Per cent.
SiO_2 . . .		52·21
Al_2O_3 . . .		2·72
Fe_2O_3 . . .		2·71
FeO . . .		17·19
MgO . . .		11·24
CaO . . .		10·89
Na_2O . . .		1·04
K_2O . . .		0·37
H_2O (below 107°C)		0·17
H_2O (above 107°C)		0·61
TiO_2 . . .		trace
MnO . . .		0·59
F . . .		0·35
		100·09
Less O . .		0·15
	TOTAL	99·94

Dr. Christie has also determined its specific gravity ($\frac{30}{4}$), as 3·126 and its refractive indices, for sodium light, to be α 1·631, β 1·649, γ=1·659 (all $\pm$ ·003), and it is optically negative.

Comparing this with the undernoted analyses it will be seen that the Kishengarh mineral is too high in silica, lime and magnesia, and too low in alumina, soda and iron for hastingsite, and approaches much more closely analyses of hornblende. The alumina content, notably low for amphibole, is rather characteristic of the amphiboles of soda-syenites. It has not the characteristic reddish colour of katoforite, and its analysis shows deficiency of iron and soda, and excess in lime and magnesia, in comparison with that mineral. It may be identified as green hornblende with an unusually high extinction angle.

[1] *Mem., Geol. Surv. India,* XXX, pt. 3, p. 187.
[2] Iddings, "Rock Minerals," p. 351. (1906).

A. Kishengarh amphibole. (W. A. K. Christie.)
B. Hastingsite, nepheline-syenite, Dunganon, Ont. (B. J. Harrington.)[1]
C. Hornblende, granitic syenite, Donegal. (S. Haughton.)[2]
D. Hornblende, syenite, Biella. (A. Cossa.)[3]
E. Hornblende, dacite, Grenatilla.[4]
F. Hornblende, diorite, Faymont, Vosges. (A. Delesse.)[5]

	A.	B.	C.	D.	E.	F.
SiO_2 . .	52·21	34·18	47·25	46·22	45·76	41·99
Al_2O_3 . .	2·72	11·52	5·65	8·12	8·80	11·86
Fe_2O_3 . .	2·71	12·62	19·11	9·33	5·32	..
FeO . .	17·19	21·98	0·91	15·18	11·23	22·22
MgO . .	11·21	1·35	11·26	5·20	14·08	12·59
CaO . .	10·89	9·87	11·76	10·08	10·62	9·7[illegible]
Na_2O . .	1·04	3·29	0·98	2·46	1·39	1·52 (with K_2O)
K_2O . .	0·37	2·29	1·04	1·23	0·26	
TiO_2 . .	Trace	1·53	..	1·08	1·43	..
MnO . .	0·59	0·63	1·70	..	0·57	..
H_2O . .	0·78	0·35		1·36	0·85	0·47
F . . .	0·35	..	..	..	..	..
Loss on ignition	..	..	..	1·36	0·85	0·47
Less O . .	0·15	..	..	..	..	..
	99·94	99·61	99·69	100·26	100·31	100·00

Pyroxene.

A bright green, faintly pleochroic pyroxene occurs as somewhat rounded grains in the syenite, but is not common. It is biaxial, and the extinction angle, X ∧ c, is about 40°, X—pale green or bright green, Y and

[1] F. D. Adams and A. E. Barlow, *Geol. Surv. Canada, Geol. ser.* 5, Mem. 6, 247, (1910).
[2] *Quart. Journ. Geol. Soc.*, 18, 416, (1862).
[3] F. Zambonini, *Zeits. f. Kryst.*, 40, 231, (1905).
[4] c f. Iddings, "Rock Minerals," 338, (1906).
[5] *Ann. des. Mines*, Ser. 4, 16, 359, (1849)

Z= yellow-green or yellow-brown. In one variety of pegmatite found south of Mandaoria large crystals of the same mineral are included in a matrix of elæolite, sodalite and microcline, in this case the extinction angle being 30°, and X= deep green, Y and Z= yellow-brown and yellow-green. It may be classified as ægirine-augite.

Garnet.

Several varieties of garnet occur. A yellowish-brown kind was seen in one microscope slide of the granitoid syenite, and melanite occurs in the dark basic bands in the banded syenite. The latter also is found in calcareous quartzite and felspar-biotite rock with calcite, the nature of which is doubtful, but which may be xenoliths or hybrid rocks. Brown garnet, resembling that associated with the monchiquite of Mount Girnar in Kathiawar occurs as veins in quartz.[1] Pale pink garnets are found in felspathic veins in the syenite, which are probably pegmatitic, associated with biotite, sphene, apatite and molybdenite (rare).

Sodalite.

Sodalite is present in two varieties, one of a beautiful blue colour, and the other colourless and transparent; some of the latter is of an evanescent pink tint when the rock is freshly broken. Both varieties occur interstitially in the elæolite-sodalite pegmatite, usually separating the large individuals of elæolite, and the colourless variety is often intimately mixed with fine granular elæolite.

Two analyses of the blue variety are appended, the first that quoted by E. Vredenburg, and the second made in the Geological Survey laboratory by B. C. Gupta on material collected by me.

	Per cent.
SiO_2	38·055
Al_2O_3	31·30
Fe_2O_3	trace.
CaO	0·001
Na_2O	24·77
Loss on ignition	0·82
Cl	7·18
SO_3	trace.
	102·126
Less oxygen equivalent of chlorine	1·618
TOTAL	100·508

	Per cent.
SiO_2	36·92
Al_2O_3	34·46
Fe_2O_3	trace.
MgO	0·17
CaO	*Nil.*
Na_2O	17·20
K_2O	5·37
H_2O	3·07
Cl	4·80
	101·99
Less oxygen equivalent of chlorine	1·08
TOTAL	100·91

[1] *Quart. Journ. Geol. Soc.*, LVII, (1901), pp. 38—54.

Cancrinite in small interstitial grains occurs in the syenite in the two most westerly outcrops, to the west of the Guest House.

Cancrinite.

It is well to note that scapolite and cancrinite are indistinguishable in small grains in thin sections unless their prismatic cleavages (hexagonal, intersecting at 60° in the case of cancrinite and tetragonal intersecting at 90° in scapolite) are observed, as their other optical properties are identical. In view however of the abundance of cancrinite in the pegmatites, there is little doubt that it is this mineral which is present in the syenite proper and not scapolite.

In the pegmatites it occurs in large individuals, sometimes a foot across, without crystal outlines but with perfect prismatic cleavage. It is white or greenish white, translucent, with pearly lustre on the cleavage faces, and weathers with a chalk-like crust as elæolite does. Sometimes it is granular and yellow, and a very striking rock is that in which this variety is associated with blue sodalite and felspars. Black biotite commonly accompanies it.

Calcite has been detected in interstitial grains among the felspars of the syenite, occurring in the same way as cancrinite. Calcite

Calcite.

occurs as an original constituent in both the Sivamalai and Vizagapatam syenites[1], and must here also be regarded as primary.

The pink mineral occurring as fibrous patches in the cancrinite-calcite contact rock near Mandaoria has presented considerable

Thulite (manganese zoisite).

difficulty in determination, as it belongs to a group, the zoisites and epidotes, which are on the boundary line between the orthorhombic and monoclinic systems, and the species of which are optically very variable and frequently anomalous, and grade rather indefinitely into each other. Macroscopically it is rose pink or pale yellowish-pink and in thin sections colourless or pale pink, in the latter case being pleochroic from pink to colourless. The specific gravity of a piece, probably slightly admixed with calcite was determined as 3·27 by weighing, and of an isolated fragment by heavy liquids as 3·30. The specific gravity of zoisite is 3·25 3·37. The refractive index β was determined by my colleague, Dr. W. A. K. Christie, as 1·711 ± ·002 and 1·700 ± ·002, on two different specimens, 1·702 ± ·002 being obtained from thulite

[1] *Rec., Geol. Surv. Ind.*, XXXVI, p. 20, (1908).
Mem., Geol. Surv. Ind., XXX, pp. 197 and 214, (1900).

from Lerviken, Norway, that given for normal zoisite being 1·699--1·720 by Luquer, 1·696—1·7058 by Iddings and 1·697—1·702 by Weinschenk and Clark. It is probably biaxial with large optic axial angle; the plane of the optic axes is perpendicular to the cleavage and the longitudinal section of the crystals shows the emergence of an optic axis. In the rock the mineral occurs as granular aggregates and felted bundles of prismatic crystals, the elongation of which is in the direction of the *c* axis. The pinacoidal cleavage, parallel to (010), is perfect, and the extinction is parallel to this cleavage; there are also two indistinct partings mutually at right angles and 15° to the cleavage direction. The double refraction is very low and the interference colours are anomalous, indigo and yellow. Twinning is frequent, the twinning plane making an angle of about 66° with the traces of the cleavage in transverse sections of the crystals, in which sections the angle between the cleavage traces and the extinction direction is 15°—18°.

An analysis of the mineral, by B. C. Gupta, is given below, with analyses of withamite (manganese epidote) and thulite, and the theoretical composition of zoisite for comparison.

—	Kishengarh mineral	Withamite.[1]	Thulite.[2]	Theoretical zoisite.
SiO_2	34·92	43·23	42·81	39·7 per cent.
Al_2O_3	33·17	23·09	31·14	33·7 ,,
Fe_2O_3	5·99	6·68	2·29	
FeO	..	1·13	..	
MgO	0·49	0·88	..	
CaO	21·13	20·00	18·73	24·6 ,,
Na_2O	0·14	0·94	1·89	
K_2O	..	0·96	..	
H_2O	..	2·40	0·64	2·0 ,,
MnO	0·86	0·14	Mn_2O_3 1·63	
Li_2O	..	0·25	..	
Insol.	..	0·35	..	
TOTAL .	100·0	99·70	100·76	100·0 per cent.

It will be seen that the analysis agrees fairly well with that of thulite and with the theoretical composition of zoisite, except that the percentage of silica is somewhat low.

[1] Heddle, *Min. Mag.*, 5, 15, (1882).
[2] Gmelin, *Poggendorff's Annalen*, 49, p. 539, (1840).

EXPLANATION OF PLATES.

PLATE 2.—FIG. 1.—Granitoid syenite, main intrusion.
FIG. 2.—Foliated syenite, near Mandaoria.
" 3.—FIG. 1.—Banded syenite.
FIG. 2. " " , showing contortion.
" 4.—FIG. 1.—Photomicrograph of granitoid syenite; × 18.
FIG. 2.—Photomicrograph of granitoid syenite; polarized light; × 18.
" 5.—FIG. 1.—Photomicrograph of granitoid syenite; × 18.
FIG. 2.—Photomicrograph of banded syenite; × 18.
" 6.—FIG. 1.—Photomicrograph of banded, biotitic syenite; × 18.
FIG. 2.—Photomicrograph of fine-grained, foliated syenite; × 18.
" 7.—FIG. 1.—Photomicrograph of ægirine pegmatite; × 18.
FIG. 2.—Photomicrograph of amphibole-garnet-pegmatite; × 18.
" 8.—FIG. 1.—Photomicrograph of sodalite in elæolite-sodalite rock; × 18.
FIG. 2.—Photomicrograph of xenolith with biotite, pyroxene and sphene; × 18.
" 9.—FIG. 1.—Photomicrograph of thulite-cancrinite-calcite rock; × 18.
FIG. 2.—Photomicrograph of thulite-tremolite-felspar rock; × 18.
" 10.—FIG. 1.—Photomicrograph of thulite-tremolite rock; × 18.
FIG. 2.—Photomicrograph of thulite-calcite rock; × 18.
" 11.—FIG. 1.—Photomicrograph of impure crystalline limestone; × 18.
" 12.—Geological map of part of Kishengarh, scale 1″ = 1 mile.

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GRANITOID VARIETY OF SYENITE
Showing characteristic weathering main intrusion near road

A M Heron Photos

G S I Calcutta

BANDED VARIETY OF SYENITE. west of Guest House.

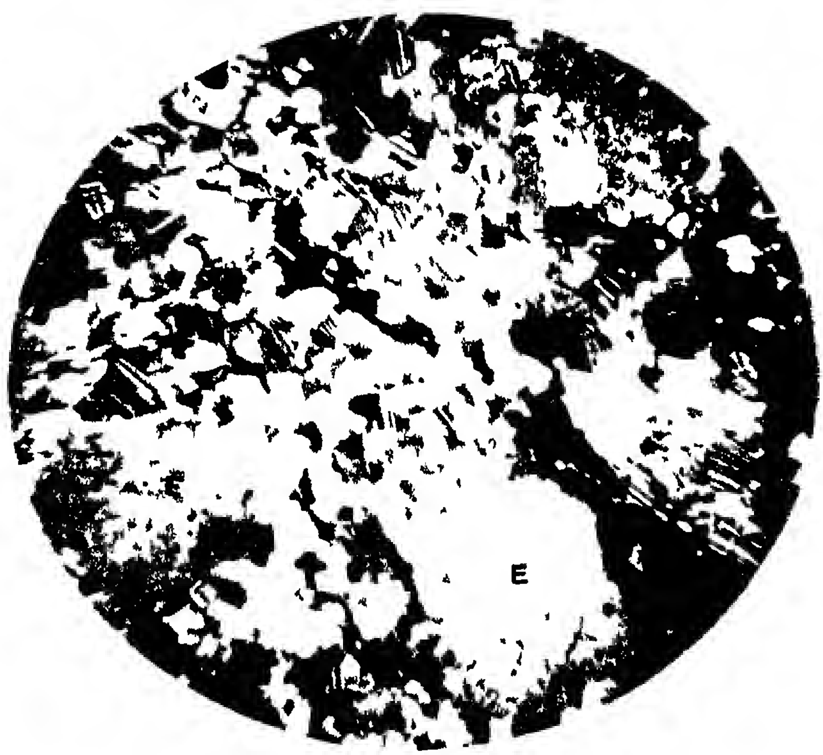
L. M. Heron, Photos

G. S. I. Calcutta

BANDED VARIETY OF SYENITE

FIG 1 NORMAL GRANITOID VARIETY OF SYENITE × 18

s sphene b biotite c calcite m microcline e elæolite p pyroxene
can—granular cancrinite Remainder of slide mainly microcline and other felspars



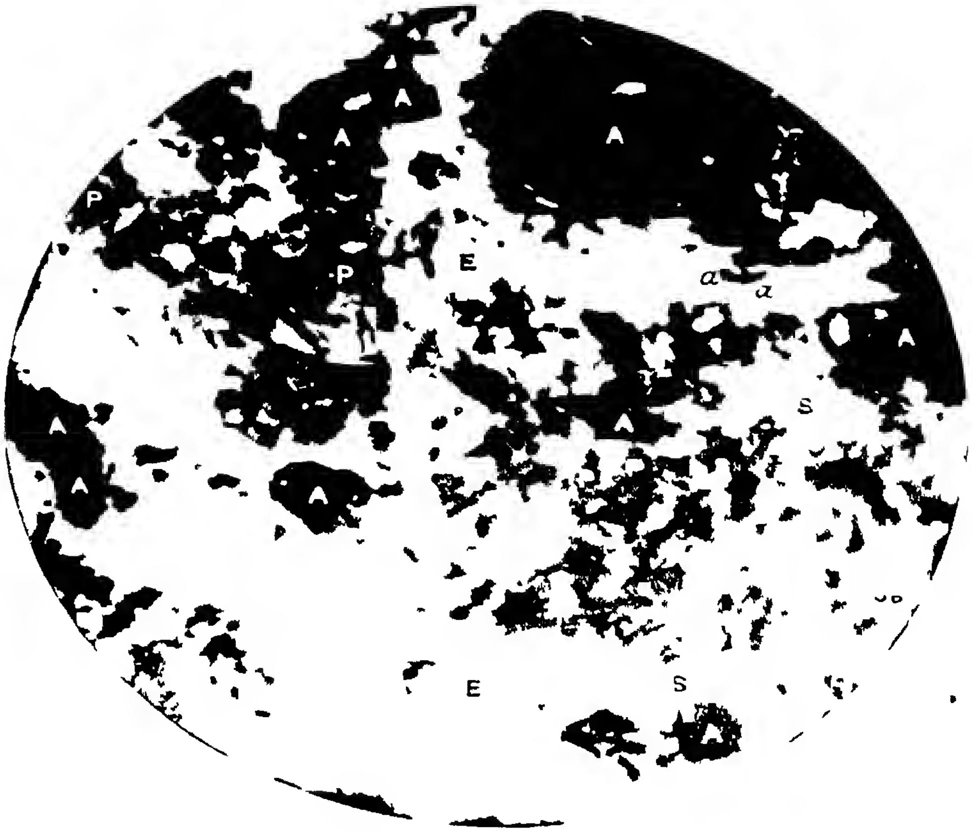


FIG 1 GRANITOID VARIETY OF SYENITE WITH MORE FERROMAGNESIAN MINERALS THAN IS USUAL

A amphibole E elæolite P pyroxene S—sphene a apatite So sodalite

FIG 1 BANDED BIOTITE VARIETY OF SYENITE
A—amphibole a—apatite b biotite Remainder of slide elaolite and microcline

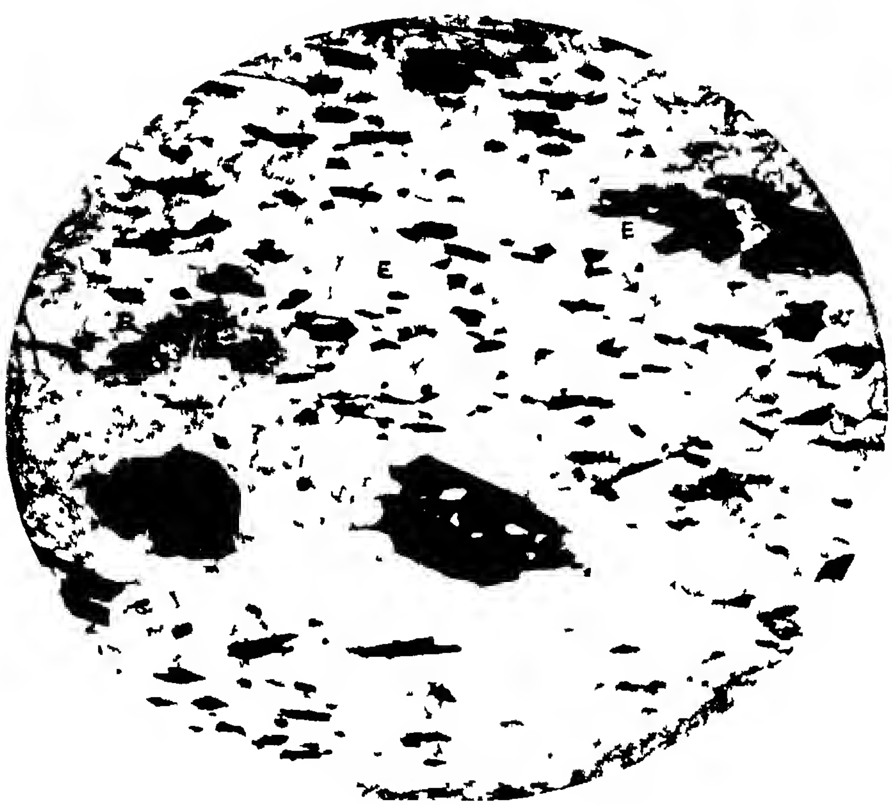


FIG 1 ÆGIRINE PEGMATITE × 18

A apatite P pyroxene (ægirine) S sodalite E elæolite
Pale portion of slide microcline and other felspars

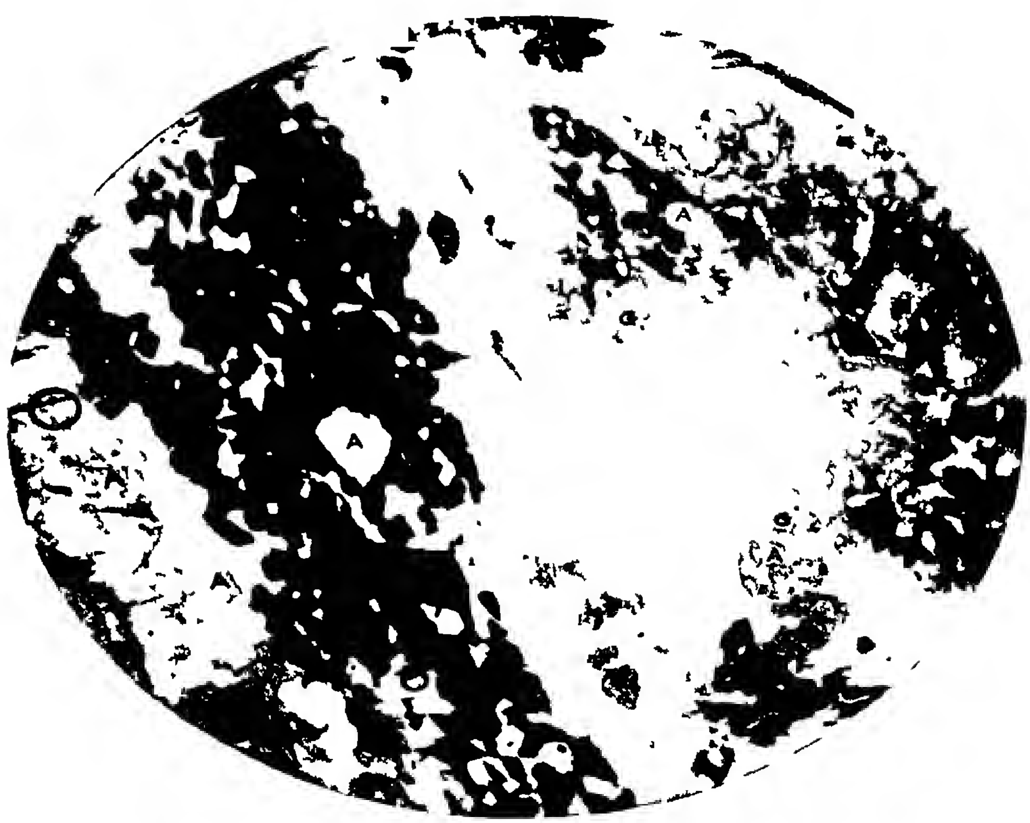


FIG 1 SODALITE VEIN (S) IN GRANULAR ELÆOLITE SODALITE ROCK × 18

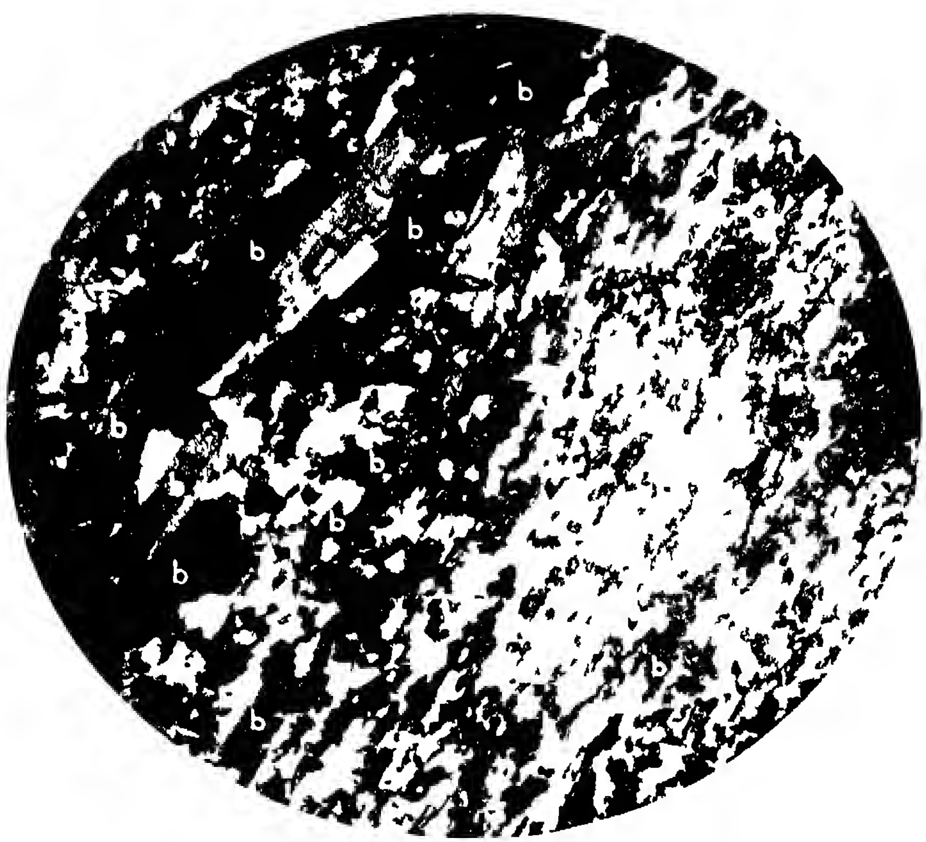
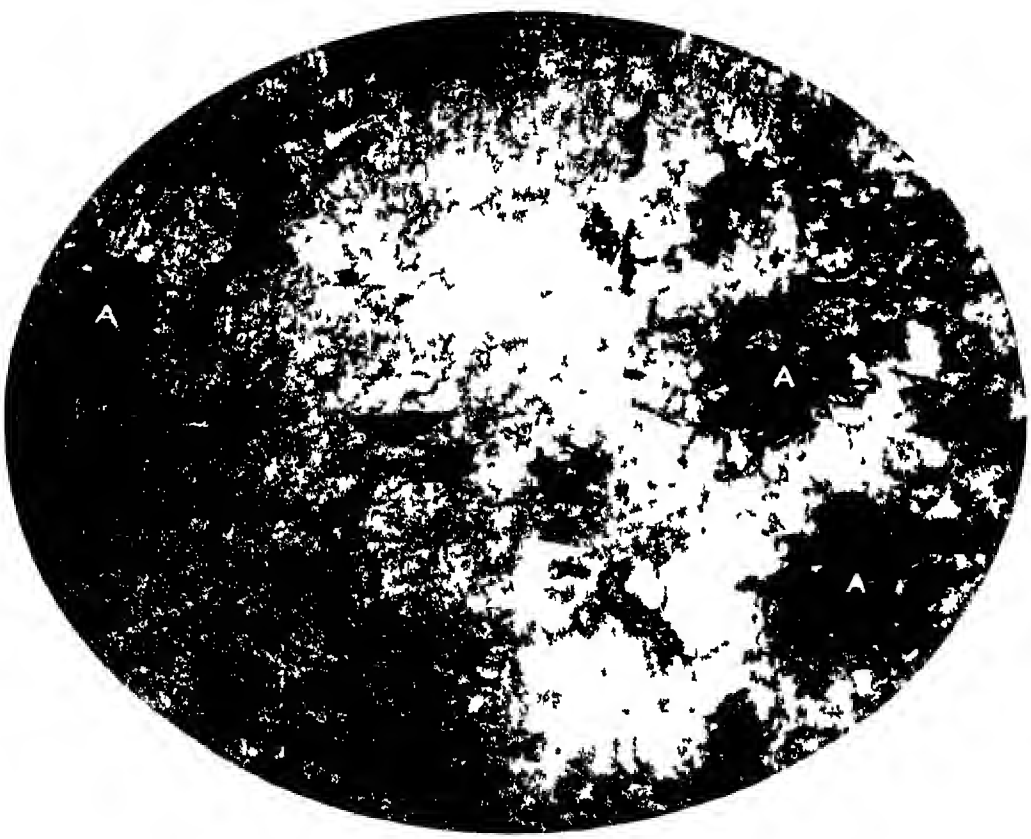
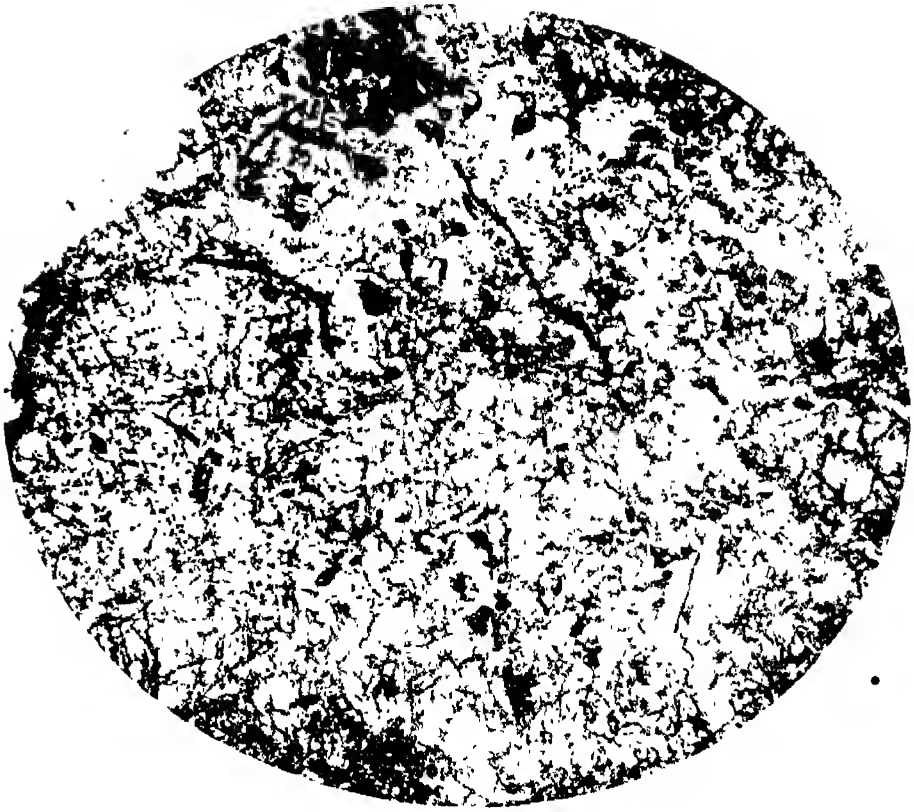


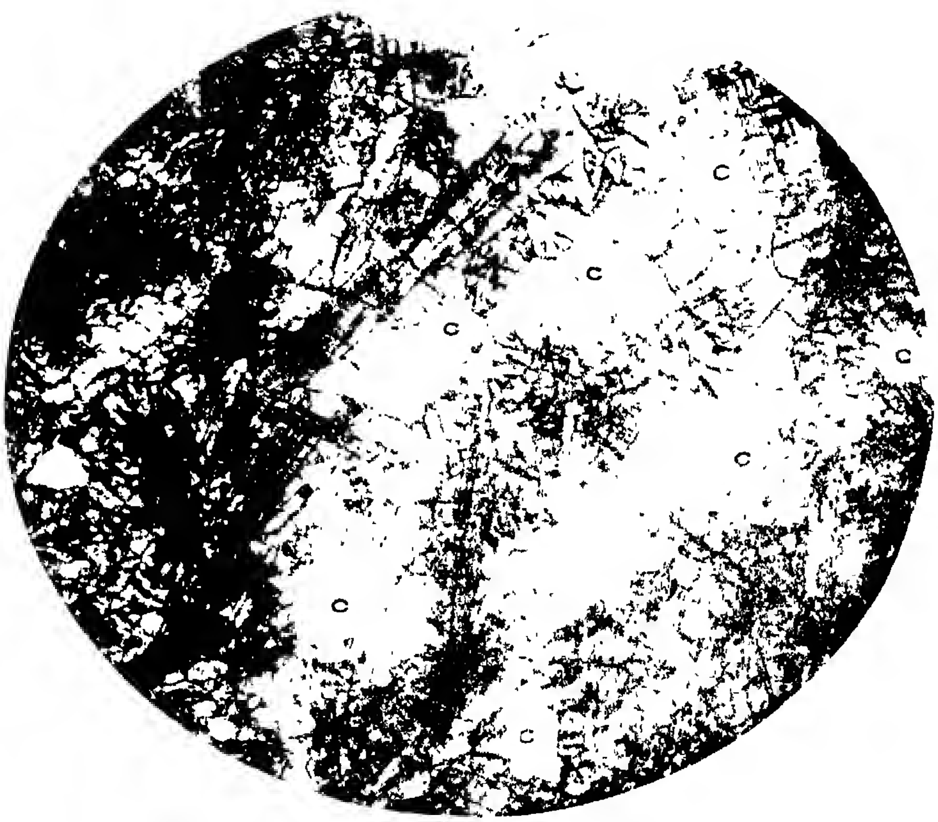
FIG 1 THULITE CANCRINITE CALCITE ROCK
Thulite (dark) with calcite and cancrinite

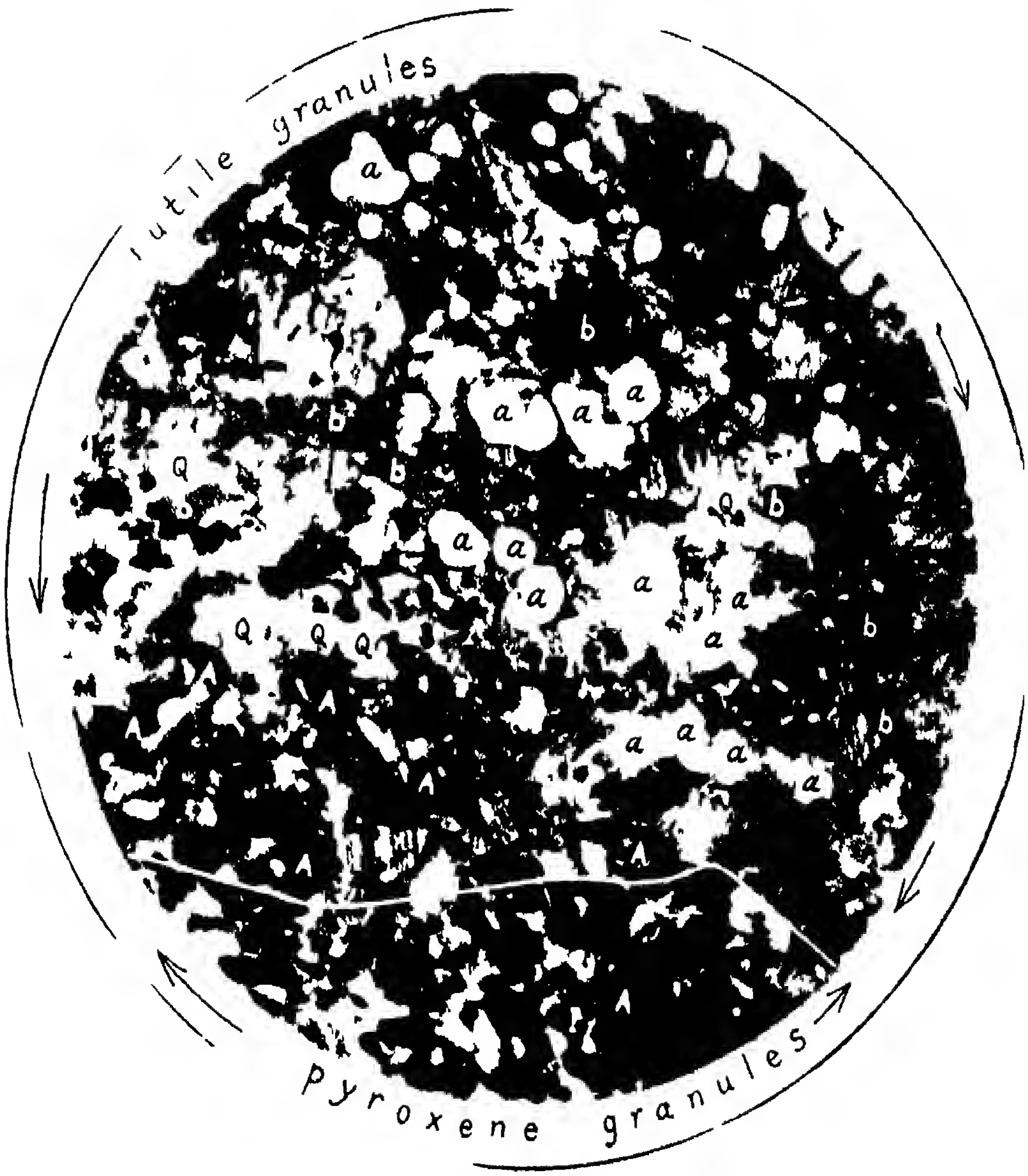




THULITE-TREMOLITE ROCK

A Thulite with amphibole (tremolite) S Grains of sphene





J. W. Heron Photos

G. S. I. Calcutta

IMPURE CRYSTALLINE DOLOMITE × 18

A—amphibole a apatite b biotite Q quartz Dark granules in upper portion of slide are rutile, in lower portion pyroxene interstitial material is calcite

Part 2 (out of print).—Rocks of the Lower Godavari. 'Atgarh Sandstones' near Cuttack. Fossil floras in India. New or rare mammals from the Siwaliks. Aravali series in North-Eastern Rajputana. Borings for coal in India. Geology of India.

Part 3 (out of print).—Tertiary zone and underlying rocks in North-West Punjab Fossil floras in India. Erratics in Potwar. Coal explorations in Darjiling district. Limestones in neighbourhood of Barakar. Forms of blowing machine used by smiths of Upper Assam. Analyses of Raniganj coals.

Part 4 (out of print).—Geology of Mahanadi basin and its vicinity. Diamonds, gold, and lead ores of Sambalpur district. 'Eryon Comp. Barrovensis,' McCoy, from Sripermatur group near Madras. Fossil floras in India. The Blaini group and 'Central Gneiss' in Simla Himalayas. Tertiaries of North-West Punjab. Genera Chœromeryx and Rhagatherium.

VOL. XI, 1878.

Part 1.—Annual report for 1877. Geology of Upper Godavari basin, between river Wardha and Godavari, near Sironcha. Geology of Kashmir, Kishtwar, and Pangi Siwalik mammals. Palæontological relations of Gondwana system. 'Erratics in Punjab.'

Part 2 (out of print).—Geology of Sind (second notice). Origin of Kumaun lakes. Trip over Milam Pass, Kumaun. Mud volcanoes of Ramri and Cheduba. **Mineral** resources of Ramri, Cheduba and **adjacent islands.**

Part 3.—Gold industry in Wynaad. Upper Gondwana series in Trichinopoly and Nellore-Kistna districts. Senarmontite from Sarawak.

Part 4.—Geographical distribution of fossil organisms in India. Submerged forest on Bombay Island.

VOL. XII, 1879.

Part 1.—Annual report for 1878. Geology of Kashmir (third notice). Siwalik mammalia Siwalik birds. Tour through Hangrang and Spiti. Mud eruption in Ramri Island (Arakan). Braunite, with Rhodonite, from Nagpur, Central Provinces. Palæontological notes from Satpura coal-basin. Coal importations into India.

Part 2.—Mohpani coal-field. Pyrolusite with Psilomelane at Gosalpur, Jabalpur district. Geological reconnaissance from Indus at Kushalgarh to Kurram at Thal on Afghan frontier. Geology of Upper Punjab.

Part 3. Geological features of northern Madura, Padukota State, and southern parts of Tanjore and Trichinopoly districts included within limits of sheet 80 of Indian Atlas. Cretaceous fossils from Trichinopoly district, collected in 1877 78. Sphenophyllum and other Equisetaceæ with reference to Indian form Trizygia Speciosa Royle (Sphenophyllum Trizygia, Ung.). Mysorin and Atacamite from Nellore district. Corundum from Khasi Hills. Joga neighbourhood and old mines on Nerbudda.

Part 4.—'Attock Slates' and their probable geological position. Marginal bone of undescribed tortoise, from Upper Siwaliks, near Nila, in Potwar, Punjab. Geology of North Arcot district. Road section from Murree to Abbottabad.

VOL. XIII, 1880.

Part 1.—Annual report for 1879. Geology of Upper Godavari basin in neighbourhood of Sironcha Geology of Ladak and neighbouring districts Teeth of fossil fishes from Ramri Island and Punjab Fossil genera Noggerathia, Stbg., Noggerathiopsis, Fstm., and Rhiptozamites, Schmalh., in palæozoic and secondary rocks of Europe, Asia and Australia Fossil plants from Kattywar, Shekh Budin, and Sirgujah Volcanic foci of eruption in Konkan.

Part 2.—Geological notes. Palæontological notes on lower trias of Himalayas. Artesian wells at Pondicherry, and possibility of finding sources of water supply at Madras.

Part 3.—Kumaun lakes. Celt of palæolithic type in Punjab. Palæontological notes from Karharbari and South Rewa coal-fields. Correlation of Gondwana flora with other floras. Artesian wells at Pondicherry. Salt in Rajputana. Gas and mud eruptions on Arakan coast on 12th March 1879 and in June 1843.

Part 4 (out of print)—Pleistocene deposits of Northern Punjab, and evidence they afford of extreme climate during portion of that period. Useful minerals of Arvali region Correlation of Gondwana flora with that of Australian coal-bearing system. Reh or alkali soils and saline well waters Reh soils of Upper India. Naini Tal landslip 18th September 1880.

VOL. XIV, 1881

Part 1.—Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts Siwalik carnivora. Siwalik group of Sub-Himalayan region. South Rewah Gondwana basin. Ferruginous beds associated with basaltic rocks of north-eastern Ulster, in relation to Indian laterite. Rajmahal plants. Travelled blocks of the Punjab. Appendix to 'Palæontological notes on lower trias of Himalayas.' Mammalian fossils from Perim Island.

Part 2.—Nahan-Siwalik unconformity in North-Western Himalaya. Gondwana vertebrates. Ossiferous beds of Hundes in Tibet. Mining records and mining record office of Great Britain; and Coal and Metalliferous Mines Act of 1872 (England)

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1925 [February.

GYROLITE AND OKENITE FROM BOMBAY. BY W. A. K. CHRISTIE, B.SC., PH.D., M.INST.M.M., *Chemist, Geological Survey of India.* (With Plate 13.)

THE minerals discussed in this paper, although not represented until recently in the collections of the Geological Survey, have both been recorded before from India.[1] Doubts have recently been thrown on the authenticity of many of the specimens of okenite in European collections [2] and the distinctive nature of the much rarer mineral gyrolite and its near relatives as mineral species has often been called in question.[3] It may therefore be worth while to describe the new acquisitions of these non-aluminous zeolites.

GYROLITE.

In an unnamed collection of minerals from the Deccan Trap of Bombay Island, acquired in 1922 by purchase from Mr. J. Ribeiro, there is a small specimen of gyrolite from Nowroji Hill [4] (19° 57′ 72° 53′). It occurs as a mammillary aggregate, the roughly hemispherical parts of which vary in diameter from 0·5 to 1 cm. The surface has a delicately chiselled appearance reminiscent of the manner in which hair is represented in sculpture. The nodules on

[1] Gyrolite from Poona: M. F. Heddle, *Mineral Mag.*, VIII, 199, (1889); F. Cornu, *Mineral. Mitth.*, XXV, 515, (1906) and *Sitz. K. Akad Wiss. Wien*, CXVI, Abt. 1, 1235, (1907). Cornu gives a partial analysis. Okenite from Poona: S Haughton, *Journ. Geol. Soc. Dublin*, II, 114, (1868), with an analysis

[2] O. B Bøggild, *Danske Vidensk. Selskab. Math. fys Meddelelser*, IV, part 8, 1, (1922)

[3] *Cf.* F. Cornu, loc cit.

[4] *Cf.* map, *Rec., Geol. Surv. Ind.*, LIV, Plate 4, (1922)

fracture show a series of irregularly overlapping plates, producing a radiate structure. The mineral has a perfect platy cleavage, thin laminæ being flexible but not elastic. The hardness is about 3. The specific gravity is 2·388-2·390 (acetylene tetrabromide and xylol, $\frac{28°}{28°}$C.). The lustre on the yellowish white, mammillary surface is dull, on the cleavage faces pearly and shining. The cleavage flakes are transparent to translucent.

The mineral is uniaxial; cleavage plates sometimes, however, show the emergence of two axes with a very small axial angle. It is optically negative. For sodium light $\omega = 1{\cdot}549 \pm {\cdot}001$, $\varepsilon = 1{\cdot}536 \pm {\cdot}002$ (embedding method with mixtures of cinnamon and clove oils, controlled with an Abbe refractometer).

Its composition is as follows :—

SiO_2 . .	52·09
Al_2O_3 . .	0·19
MgO . .	0·29
CaO . .	33·07
SrO . .	0·05
Na_2O . .	0·51
K_2O . .	0·01
H_2O below 107°C	2·99
H_2O above 107°C	10·36
	99·86

It contains no fluorine. The composition is in reasonable agreement with the original formula of T. Anderson,[1] 2 CaO, 3 SiO_2, 3 H_2O, with SiO_2 52·12 per cent., CaO 32·31 per cent. and H_2O 15·57 per cent.; it is somewhat nearer to that of F. W. Clarke,[2] $Ca_4(Si_2O_7)_3H_{10}$, with SiO_2 53·51 per cent., CaO 33·17 per cent. and H_2O 13·32 per cent.

O. B. Boggild[3] has determined gyrolite as tri-rhombohedral, although it appears that the material on which alone measurements were possible is held by F. Cornu and A. Himmelbauer[4] to be a distinct mineral, reyerite. My attempts to ascertain the symmetry from percussion and etched figures on cleavage plates were unsuccessful.

[1] *Phil. Mag.*, 4th Ser., I, 113, (1851).

[2] *Bull. U. S. Geol. Surv*, DLXXXVIII, 108, (1914)

[3] Author's abstract in *Zeits. f. Kryst.*, XLVIII, 534, (1911), from *Meddelelser om Grønland*, 34, 91 et. seq., (1908).

[4] *Mineral Mitth.*, XXV, 519, (1906) and A. Himmelbauer in C. Doelter Handbuch der Mineralchemie, II, 471, (Dresden, 1914).

The double refraction is considerably higher than the only value previously recorded,[1] ·0055 (ω=1·5645, ε=1·5590), but there again the determination was apparently on reyerite of Cornu and Himmelbauer, who give for that mineral ω=1·564 and an analysis resembling that of Boggild's material. Himmelbauer gives values of ω for gyrolite varying from 1·540 to 1·548.

The gyrolite occurs with calcite, apophyllite and okenite. The calcite gives one the impression of having been the first to crystallize, gyrolite nodules being attached to plane crystal faces. Thin sections from other parts of the specimen, however, show this apparently abnormal sequence[2] to be illusory; there calcite is seen to be enveloping and replacing gyrolite. Projecting from the gyrolite nodules and later than them are many crystals of apophyllite (ε 1·536 ±·001, positive), showing (100), (001) and (111), some of them double-ended, attached by a prism face. Likewise later than the gyrolite and perched on the top of it are three little tufts of fibrous okenite, between 2 and 3 mm. in diameter and very similar to that described below. The fine projecting spicules have straight extinction, positive elongation and η about 1·541. In one instance okenite spicules are seen penetrating and included in a crystal of apophyllite. The order of crystallization was probably gyrolite, okenite and apophyllite, calcite.

OKENITE.

The beautiful specimens of this mineral here described were collected by Dr. C. S. Fox in 1921 in a quarry in the Deccan Trap at the north-eastern foot of Golangi Hill[3] (19° 0′; 72° 54′) on Bombay Island. The okenite occurs with other zeolites in large geodes in somewhat soft, green basalt, probably intrusive at a horizon of intertrappean, carbonaceous shales.

It occurs as an aggregate of fibrous, radiate nodules up to 3 cm. in diameter, whose mammillary surfaces have a delicate, furry covering of prismatic crystals of the same mineral, the furry spicules being up to 1·5 mm. in length and varying in thickness from 0·001 mm. to 0·02 mm. The delicate fibres forming the bulk of the nodules show a general radiate arrangement, although the fibres

[1] Boggild, loc. cit.

[2] *Cf.* C. N. Fenner, *Ann. N. Y. Acad Sci.*, XX, 175, (1910) and T. L. Walker and A. L. Parsons, *Univ. Toronto Studies*, Geol. Ser., No. 14, 29, (1922).

[3] *Cf.* map, *Rec. Geol. Surv. Ind.*, LIV, Pl. 4, (1922).

are usually finely interlaced. This interlocking probably accounts for the toughness of the nodules; the inner surfaces of broken nodules, however, can be disintegrated easily with the finger nail. The fibrous material is pure white and opaque, with a pearly lustre. The tiny prismatic crystals are lath-shaped and often longitudinally striated; they are colourless and transparent. When gently rubbed between two glass surfaces they show a perfect longitudinal cleavage and signs of a transverse one approximately at right angles to this. The specific gravity of the fibrous material is 2·302 ($\frac{30°}{4°}$), (specific gravity bottle and vacuum). The refractive index of the lath-shaped crystals is 1·540 in one direction of extinction and 1·542 with the lower nicol rotated through 90°—determined in mixtures of clove and cinnamon oils at 30°C. in sodium light and controlled with an Abbe refractometer. They have apparently straight extinction, but individual spicules are so thin that an obliquity of several degrees would not be observable. The elongation is positive.

The fibrous material has the following composition.[1]

		Molecular ratios.		Calculated.
SiO_2	53·88		·894	·940
Al_2O_3	0·08			
Fe_2O_3	0·01			
CaO	27·61	·492	·498	·470
SrO	0·27	·003		
K_2O	0·06	·001		
Na_2O	0·12	·002		
H_2O, below 106°C.	6·36		1·000	·940
H_2O, above 106° C.,	11·66			
	100·05			

It contains no fluorine. The SiO_2 is about 3 per cent. low, RO is about 1½ per cent. high and H_2O about 1 per cent. high compared with the theoretical composition of okenite of the accepted formula CaO, 2 SiO_2, 2 H_2O, with 56·70 per cent. of SiO_2, 26·36 per cent. of CaO and 16·94 per cent. of H_2O.

The other minerals present are apophyllite and laumontite (see Pl. 13, fig. 2). The apophyllite is in well developed crystals up to 1·5 cm. square, showing (100), usually striated, (111) and (001). The laumontite is rather weathered and extremely friable. It has a good prismatic

[1] I am indebted to Professor A. Lacroix for permission to make this analysis in his laboratory in the Muséum national d'Histoire naturelle, Paris.

cleavage and the characteristic $(\dot{2}01)$ cleavage. $\eta\beta$ for sodium light is about 1·515[1]; the optical character is negative. The paragenesis is not easy to determine. In thin sections[2] the okenite fibres are seen penetrating the apophyllite and certainly seem to be replacing it. Again, idiomorphic apophyllites, jutting out of okenite nodules are seen, when the surrounding okenite is removed, to have lost their idiomorphic character wherever the two minerals are in contact,—and often the contact persists to the centre of the okenite spherules. There is, however, just as definite evidence against growth by replacement; in a cavity protected from abrasion is a small apophyllite crystal with uncorroded prism, pyramid and basal plane faces, from which project scores of undoubted okenite spicules, firmly attached, showing at any rate that the growth of okenite was not incompatible with the persistence of unaltered apophyllite (see Pl. 13, fig. 3); while on another specimen from Nowroji Hill collected by Mr. J. Ribiero, a tiny, perfect crystal of apophyllite is seen poised on two needles of okenite. Probably conditions did not present an irreversible sequence. With minerals so similar in composition a slight change in temperature, in pressure, in concentration of any of the components of the system, might alter the necessary conditions for deposition of one mineral to those for re-solution of that and crystallization of the other, while a subsequent change allowed formation of the second without mutilation of the first or even, at a transition point, of simultaneous crystallization of both. Possibly the presence or absence of fluorine was one of the controlling factors. A careful search for fluorine on 2 g. of okenite by the amended method of Berzelius,[3] showed its absence. 0·02 per cent. was found by the method of F. Pisani,[4] but this not qualitatively confirmed. In apophyllite from the same specimen 0·94 per cent. of fluorine was found by the Berzelius method.

Laumontite appears to be the earliest of the three zeolites being found between trap and okenite and sometimes as a nucleus of the okenite spherules.

[1] *Cf.* E. S. Larsen, *Amer. Mineralogist*, VI, 7, (1921).
[2] Prepared at ordinary temperature by the vacuum method of E. A. Wülfing, *Centralbl. Min. Geol. u. Pal.*, 1920, 317.
[3] *Cf* W. F. Hillebrand, *Bull. U. S. Geol. Surv.*, DCC, 222, (1919)
[4] *C. R. Ac. Sci.*, CLXII, 791, (1916).

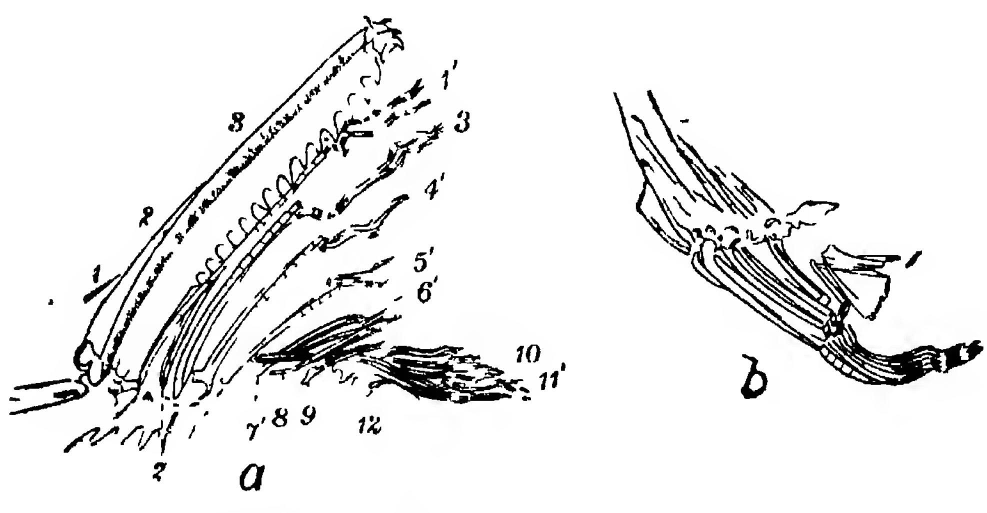
A FRESHWATER FISH FROM THE OIL-MEASURES OF THE DAWNA HILLS. BY THE LATE N. ANNANDALE, C.I.E., D.SC., F.R.S., F.A.S.B., *Director* & SUNDAR LAL HORA, D.SC., *Assistant Superintendent, Zoological Survey of India.* (With Plate 14.)

THE fish described in this note was collected by Professor J. W. Gregory, F.R.S., at Mepale in the Dawna Hills, Tenasserim. Its remains are preserved in stiff clay evidently of lacustrine origin and associated with the limestone in which the shells [1] from the same locality which one of us has recently described were obtained. The type-specimen will be returned to Glasgow University.

The species evidently belongs to the family Cyprinidæ and we believe to the subfamily Cyprininæ, but its characters are so distinct that a new genus must be set up for it. We propose for it the name :—

DAUNICHTHYS, gen. nov.

The head is large and about as deep as the body. It was apparently flattened above with the eyes in its upper half. The jaws are not suctorial. The body is short and moderately deep.



TEXT-FIG. 1.—Dorsal and anal fins.

(*a*) Dorsal fin ;
(*b*) Anal fin.

1, 2, 3 bony spines of the dorsal ; 1'-12' branched and flexible rays of the dorsal.

[1] Annandale, *Rec. Geol. Surv. Ind.*, LV, pp. 97-104, (1923).

There are at least 31 vertebrae, of which 13 appear to be caudal and the caudal and trunk regions are about equal in length. The lateral line runs along the tail below the vertebral column.

The dorsal fin is situated near the middle of the body and is of moderate length. There are at least 15 rays, of which about 12 are branched. The last bony ray is stout and strongly serrated in its upper two-thirds. The caudal fin is long and deeply notched, with the two halves pointed and equal. The ventral lies below the dorsal and has more than six rays, none of which is strongly developed. The anal, which is situated behind the dorsal, is of moderate length and contains two unbranched and 9 branched rays. There is no trace of scales in the specimen.

DAUNICHTHYS GREGORIANUS, sp. nov.

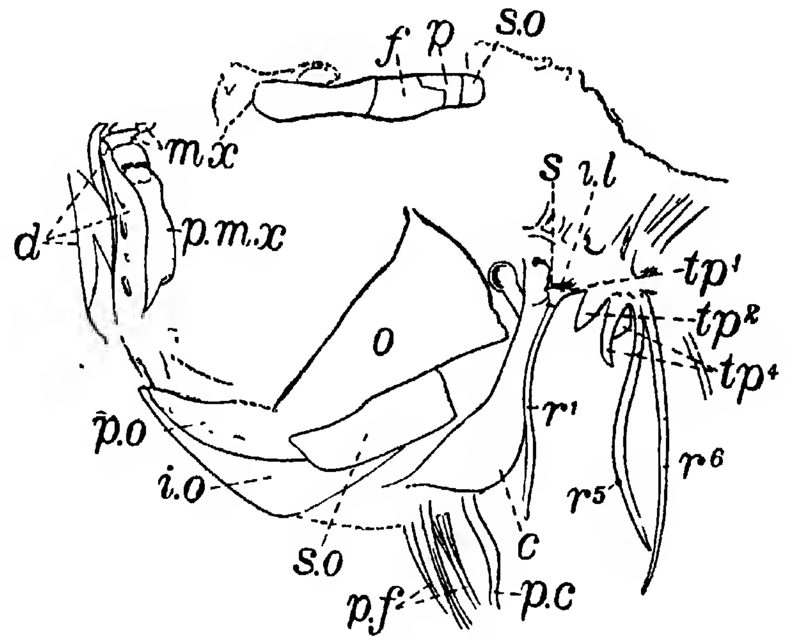
D. 3/12; A. 2/9; P. 7+; V. 6+; C. 30.

The length of the head is contained 3 times in the total length without the caudal fin. It is as deep as the body. The greatest depth of the body is contained a little over 3 times in the total length without the caudal. The dorsal fin was probably as high as the depth of the body below it. Its first bony ray is short, the second of moderate length and the third much longer and deeply grooved throughout its length. The branched rays of this fin and certain rays of other fins are longitudinally grooved. The pectorals and the ventrals are widely separated and cannot have overlapped. The commencement of the anal is nearer to the ventrals than to the base of the caudal.

The total length of our example is 56 mm., that of the head 14·2 mm., the greatest depth of the body 11 mm., and the length of the caudal fin 13 mm.

Having thus described the genus and the species we will now proceed to examine the specimen in greater detail.

Skull and associated structures:—In the region of the head the jaw-bones, the opercular bones, the secondary pectoral arch and the bones of the brain-case can be distinguished after careful examination, but the other bones have been completely broken up. It seems, however, quite probable that there was a complete circum-orbital ring for traces of it can still be made out. Of the jaw-bones, the lower jaw is broken in the middle longitudinally, while the dentary of the unexposed side, which is also visible, is further broken into two pieces. The maxillaries are represented by nodule-like bones at the top of the premaxillary, which is closely approximated to the dentary. From the direction of the jaws, which are directed



TEXT-FIG. 2.—Bones of the jaws, operculum etc., and the anterior modified vertebrae. *d* = dentary; *mx* = maxilla; *p. mx* = premaxilla; *p. o.* = preoperculum; *i. o.* = interoperculum; *s. o* = suboperculum; *o.* = operculum; *p. f* = pectoral fin; *p. c.* = post clavicular process; *c.* = cleithra; tp^1 = transverse process of first vertebra; tp^2 = transverse process of second vertebra; tp^4 = transverse process of fourth vertebra; r^1 = rib of first vertebra; r^5 = rib of fifth vertebra; r^6 = rib of sixth vertebra; *s* = scaphium; *i. l.* = interossicular ligament; *f* = frontal; *p* = parietal; *s. o* = supraoccipital.

almost vertically upwards in the specimen, it is evident that the mouth-opening must have been directed obliquely upwards as in the living *Catla*. The four opercular bones are quite clear and are well developed. It seems to be quite clear from the position of these bones that they have been detached from the jaw-bones *post mortem* and have been pushed backwards and downwards by external pressure. The secondary pectoral arch is complete and well developed. It is not emarginate anteriorly, but exhibits a somewhat primitive form of the cleithra.[1] The rib-shaped post-clavicular process of the secondary arch is also well marked. Lying alongside the posterior border of the cleithra is a rib-shaped structure, which in all probability represents a rib of the first vertebra, for we know of no other similar structure in this position in the living fishes.

[1] Regan, *Ann. Mag. Nat. Hist.*, (8) VIII, p. 28 (1911).

The brain-case is cracked in several places, but the supraoccipital, the parietal and the frontal can be made out.

Vertebral Column :—In considering the vertebral column of a Cyprinoid fish the chief interest lies in the modification of the anterior vertebrae.[1] This fossil specimen is unique, so far as we are aware, in having a rib of the first vertebra distinct and well developed. The existence of a separate distinct first rib is a very primitive character, but even in living forms the first vertebra possesses a well developed transverse process and in *Catla catla* this is usually an elongated rib-like structure, reaching to about the middle of the transverse process of the second vertebra. The scaphium and a portion of the inter-ossicular ligament of the weberian apparatus are also seen in our specimen slightly above the origin of the rib of the first vertebra. All the trunk vertebrae are covered with skin and muscles and it is difficult to make out their exact structure. Those of the tail region are very clear and are exactly similar to the tail-vertebrae of such fishes as *Labeo rohita*, *Barbus tor* and *Catla catla*. The skeleton of the caudal fin is also similar to that of these species.

Integument.—We can find no trace of scales either detached or *in situ*, but the lateral line is quite clear in the anterior half of the body and can be traced along the caudal peduncle. It lies below the vertebral column and has a slight downward curvature anteriorly, while on the tail it seems to have been nearly straight and to have run parallel to and just below the vertebrae.

Affinities of Daunichthys:—From what has been said above it is abundantly clear that the new genus belongs to the family Cyprinidae and probably to the subfamily Cyprininae. The following combination of characters, however, distinguishes our new genus from all living and fossil genera of the family.

The anal fin is provided with 9 branched rays and does not extend to below the dorsal; the lateral line runs below the vertebral column and in the tail it was probably situated in the lower half of the body; the dorsal fin possesses 12 branched rays and 3 spines, the last spine is deeply grooved longitudinally on the right side and is strongly denticulated posteriorly and the body is entirely scaleless.

In its general facies *Daunichthys gregorianus* resembles certain species of the genus *Barbus* (*s. l.*) and in its up-turned mouth those

[1] Hora, *Journ. As. Soc. Bengal*, (*n. s.*) XVIII, pp. 1-4 (1922).

of *Catla*. Neither *Barbus* nor *Catla*, however, possesses more than six branched rays in the anal fin and both are provided with well developed scales.

A deeply grooved dorsal spine is characteristic of certain living scaleless North American genera of Cyprinoid fishes such as *Meda* and *Plagopterus*. In these this spine is, however, composed of two rays, "the posterior received into a longitudinal groove of the anterior."[1] In the only scaleless Cyprinid fish of the Oriental Region (*Sawbwa resplendens* [2] from the Southern Shan States) the dorsal spine is not grooved and is normal in every respect.

In the following table are given some of the chief characters in which the fossil Cyprinid genera of the Oriental region are distinguished from one another. Of the other fossil genera of the family,[3] some are known from America and others from Europe. Most of these are either described from the remains of the pharyngeal bones and teeth or are characterized by the possession of a long dorsal fin without an osseus spine. In none of these in which the dorsal fins are preserved, are the rays grooved like those of *Daunichthys*.

The Geological Survey of India has recently received from a boring in the Tenasserim coalfield at Kawamapyin, Mergui, certain samples of clay very similar to that in which *Daunichthys* is preserved. They were obtained at a depth of 208 feet. They contain fish spines, which at first sight are very similar to the last bony ray of *Daunichthys*, but closer examination shows that they differ in not being grooved as well as minor characters. It is impossible to assign them to any genus or family with certainty, but they are probably from a dorsal fin of a Cyprinid.

[1] Jordan and Evermann, *Bull. U S Nat. Mus.*, XLVII, Part 1, p. 328 (1896).

[2] Annandale, *Rec. Ind. Mus.*, XIV, p. 48 (1918).

[3] For an up-to-date list of fossil genera of the family Cyprinidae see names in italics in Jordan's *Classification of Fishes*, pp. 139-144 (Stanford University, California : 1923).

*Thynnichthys.**	*Amblypharyngodon.**	*Barbus* (s. l.).*	*Hexasephus.*†	*Brachyspondylus.*‡	*Daunichthys*, gen. nov.
Dorsal without osseous ray, with 10-12 branched rays.	Dorsal without osseous ray, with 7-8 branched rays.	Dorsal with or without osseous ray, the last osseous ray may or may not be strongly denticulated; with 7-9 branched rays.	....	One osseous ray and 8 branched rays in dorsal.	**Dorsal with 3 osseous rays, the last being grooved and strongly denticulated posteriorly; with 12 branched rays.**
Anal with 5 branched rays.	Anal with 5, 6 branched rays	Anal with 5 branched rays.	....	Anal with 10 branched rays.	Anal with about 9 branched rays
Ventrals commencing below dorsal.	Ventrals commencing in advance of dorsal.	Ventrals below root of dorsal.	.....	....	Ventrals slightly behind commencement of dorsal.
Anal entirely behind dorsal.	Dorsal extending nearly to commencement of anal	Anal behind dorsal.	....	Anal behind dorsal.	Anal behind dorsal.
Scales present.	Scales present.	Scales present.	. .	(No indication of scales in the figure.)	No scales.
Pharyngeal teeth with a flat, oblong crown; 5 or 4, 4 or 3. 3 or 2-2 or 3, 3 or 4, 4 or 5.	Pharyngeal teeth molariform with flats or concave crown: 3, 2, 1-1. 2, 3.	Pharyngeal teeth uncinate or spoon-shaped; 5. 3, 2-2. 3, 5.	Pharyngeal bone with 3 large mammaliform teeth arranged in a single series.		

* We have followed Day's *Fishes of India* in our definitions of these genera, which still persist, but *Barbus* is broken up by some (not by all) recent ichthyologists into a number of smaller genera (see Weber and Beaufort's *Fishes of the Indo-Australian Archipelago* III, pp. 89-238 (1916).
† Marck, *Palaontographica*, XXII, p. 411, pl. xxiii, fig. 2: pl. xxiv, fig. 2 (1876).
‡ Günther, *Geol. Magazine* (n. s.) III, p. 439, pl. xvi, figs. 2, 3a, 3b, 3c (1876).

ON A FOSSIL AMPULLARIID FROM POONCH, KASHMIR. BY B. PRASHAD, D.SC., *Officiating Superintendent, Zoological Survey of India.* (With Plate 15.)

SOME opercula of a Gastropod mollusc recently sent me by Mr. D. N. Wadia, Assistant Superintendent, Geological Survey of India, consist of beautifully preserved and cleaned specimens of an extinct species of apple-snails of the genus *Pachylabra* Swainson. The occurrence of a species of this genus so far north in India is of great interest.

The genus *Pachylabra* [1] is, at the present day, represented by a number of species all over Peninsular India with the exception of Hyderabad, in Assam, Burma and the greater part of the Gangetic Plain. In the Gangetic Plain the range of distribution is limited by a line uniting Lucknow to Aligarh and then running south-west through Bharatpur and Ajmer in Central India to midway between Bombay and Ahmedabad in the Bombay Presidency. In spite of careful collecting at different times, I have failed to find specimens anywhere round Delhi, above Lucknow in the United Provinces, or in the Punjab and Kashmir. The fossil opercula brought back by Mr. Wadia from the Kashmir territory point to a greatly extended range of distribution of the family in former times. This is substantiated by the subfossil specimens of the opercula of an Ampullariid discovered in the Salt Range of the Punjab some years ago by the late E. Vredenburg. Unfortunately none of these specimens is now available for comparison and description.

The fossil opercula from Poonch, Kashmir, represent an undescribed species for which I propose the name *Pachylabra prisca*. The operculum of *P. polita* (Deshayes)—a species from Tonkin, Cambodia and Indo-China—was described by Houssay [2] in detail and the operculum of *P. prisca* resembles it in essentials, but differs in certain well-marked characters. It is also different from that of the common Indian species *P. globosa* (Swainson), which I figure here for comparison.

[1] See Preston, *Fauna Brit. India Freshw. Mollusca*, pp. 96-103 (1915), and Kobelt, Martini and Chemn. *Conch. Cab.* (ed. Küster and Kobelt) *Ampullariidae*, pp. 71-105, (1912-13).

[2] *Arch, Zool. Exper. Gen.* (II ser.) II, p. 232, pl. xi, figs. 4, 10, 11 (1884).

The operculum of *P. prisca* is a concentric, patelliform, calcareous plate of somewhat pyriform shape. The nucleus, which is only to be made out on the external surface, lies near the middle of the plate, quite close to the inner margin, and is surrounded by 7 to 8 rings of growth, which may correspond to the age of the individual. Internal to the nuclear area is the narrow nearly straight region, which, as has been shown by Houssay, is secreted by the posterior part of the foot and consists of vertical plates lying one over the other. Externally this region in *P. prisca* is much narrower than the corresponding one in *P. globosa*. The area external to the nuclear region is secreted by the anterior part of the foot of the animal and is laid in horizontal layers; it is this region which increases in size with the age of the animal and shows the regions of growth. Internally the nuclear region is not distinguishable and its place is taken up by an ovoidal area for the attachment of the opercular muscle. The muscle is mainly attached to a depressed narrow area along the margin and in the centre there is a smooth raised region. In *P. prisca* as compared with *P. globosa* the ring of attachment is more excavated and extensive, while the central smooth region is more raised and convex. The opercula of *P. prisca*, compared with those of *P. globosa*, as seen in photographs of the side views of both species reproduced in Plate 15, figs. 2*b*, 3*b*, are very much thicker and consist of many layers. This appears to indicate that they belong to a species which lived in areas liable either to desiccation and a long dry season or to a long cold winter, in which it was necessary for the preservation of the species to close the mouth of the shell tightly.

Type-specimens:—In the collections of the Geological Survey of India.

According to Mr. Wadia, the thick calcareous opercula were found *in situ* in soft, grey, micaceous sandstone interbedded with bright brick-red clay-shales similar to those characteristic of the Lower Siwalik (Chinji) series, about 1½ miles south-west of Palandri, in the bed of the stream below Phalian village and some 200 yards north of the junction of the Palandri stream. The exact horizon of these beds is in course of investigation by Dr. Pilgrim.

The Gastropod remains were associated with relics of a rather varied vertebrate fauna found in the same vicinity within a few yards, including :—

Cheironeryx silistoensis,—molar and pre-molar.

Rhinoceros mandibular ramus with 1 premolar and 2 molars.

,, incisor fragments.

Chelonia—large number of scutes and plates of the carapace and skull-bones.

Crocodilia—bones and limb-bones.

Snake—vertebrae.

Fish—vertebrae.

Ampullariid—opercular.

EXPLANATION OF PLATE 15.

FIGS. 1, 1a.—Outer, and inner views of the operculum of the type-specimen of *P. prisca*, sp. nov.

FIGS. 2, 2a, 2b.—Outer, inner and lateral views of another operculum of the same species.

FIGS. 3, 3a, 3b.—Outer, inner and lateral views of the operculum of a specimen of *P. globosa* (Swainson) from Calcutta.

All the figures are direct photographs of the opercula and with the exception of 2b are of the natural size of the specimens, Fig. 2b is enlarged twice natural size.

ON A CALCAREOUS ALGA BELONGING TO THE *Triploporelleæ* (*Dasycladaceæ*) FROM THE TERTIARY OF INDIA. BY JOHN WALTON, M.A., *Lecturer in Botany, Manchester University.* (With Plate 16.)

THE name *Triploporelleæ* was given by Oltmanns [1] to a group of fossil algæ, represented by the single genus *Triploporella*, which he considered to be a subdivision of the family *Dasycladaceæ*. The *Siphonocladiales* (which include the *Dasycladaceæ*) differ principally from the other divisions of the *Chlorophyceæ* (Green Algæ) in being infrequently septate; and when septation occurs it is quite independent of nuclear division, the segments containing several nuclei. Generally in this group the more frequently septation occurs the greater is the number of branches and the complexity of the thallus. In the *Dasycladaceæ* there is a strict symmetry in the organisation of the thallus. There is a large axial segment, which bears closely placed branches arranged in whorls; these again may bear smaller branches. The thallus in many of the genera is encrusted with calcium carbonate. Among the subdivisions of the *Dasycladaceæ* the *Dasycladeæ* and *Bornetelleæ* are among living types the closest to the *Triploporelleæ* which Oltmanns regards as intermediate to these two groups.

The material on which the following description is based was sent to Prof. Seward by the Director, Geological Survey of India, together with descriptive notes and illustrations by Mr. B. B. Gupta, Sub-Assistant in that Department: it was collected by the late Mr. Vredenburg from the Ranikot Beds in Sind, which are correlated with the lower Eocene of Europe. The material consists of several separate segments of a narrowly ovate shape (Pl. 16, figs. 1, 2, 3, 4). Those that are complete vary from 4-5 mm. in length and have a maximum diameter at the broadest end of 2·5 mm.

In shape the segments resemble those of *Ovulites margaritula* Lamarck sp.,[2] a branching calcareous alga from the Lower and Middle Eocene of France, Hungary, Belgium, and Italy which Munier-Chalmas [3] considered to be generically identical with *Penicillus* (*Coralliodendron*, Kutz.). Whatever the relationships of

[1] Oltmanns, 1904, p. 277.
[2] Lamarck, 1816. (*See* Seward, 1898.)
[3] Munier-Chalmas, 1880.

Ovulites may be, our fossil is certainly not allied to *Penicillus*, one of the *Codiaceæ*, but must be ascribed to the family *Dasycladaceæ* and to its subdivision the *Triploporelleæ*, (Oltmanns).[1] Nevertheless the occurrence at both ends of the segment of depressions suggests a jointed habit such as is found in the recent genera *Penicillus* and *Halimeda*[2] of the *Codiaceæ* and in *Cymopolia*[3] one of the genera of the *Bornetelleæ* (*Dasycladaceæ*). Mr. Gupta pointed out that there are two depressions at the larger end of one of the segments (Pl. 16, fig. 5) and this may be taken as additional evidence of a dichotomous type of branching such as has been described for *Ovulites*. This segmented branching habit is not known to occur in the other two members of the *Triploporelleæ*. In both Steinmann,[4, 5] describes club-shaped plants with no indication of any continued proliferation of the axis. However in *Triploporella Fraasi*, Steinmann,[6] (Upper Cenomanian) a very long segment is figured with slight constrictions. It may be that these constrictions are foreshadowings of the definite jointed structure found in *Cymopolia* and in our Tertiary form, for which the specific name *ranikotensis* is proposed. In longitudinal section each segment is seen to consist of a single siphon, the diameter of which is very nearly one-third the diameter of the segment as represented in the fossil. From this central siphon lateral branches are given off in whorls (Pl. 16, figs. 8, 9). The section shown in fig. 9, which is transverse to the axis of the segment, passes in a median plane through each of the 15 branches. It will be seen (figs. 6, 10, 12) that the members of successive whorls are usually alternate. The primary branches, the lower portions of which are shown in figs. 8, 9 are marked out by the different nature of the calcareous matter of the fossil between the branches of the first order. This calcareous matter may confidently be assumed to represent the secretion of calcium carbonate on the exterior surface of the cell-wall of the axial siphon and its primary branches; the calcium carbonate deposit is white and opaque whereas the carbonate which fills the lumen of the siphon and its first-order branches is fairly transparent. The preservation is not good and it is doubtful whether

[1] Oltmanns, 1904, p. 277.
[2] Oltmanns, 1904, p. 295.
[3] Oltmanns, 1904, p. 276, Fig. 170, 3.
[4] Steinmann, 1880. (*T. Fraasi*).
[5] Steinmann, 1903. (*T. Remesi*).
[6] Steinmann, 1880, Fig. 1, p. 138.

one, can distinguish the pores which must have existed between the axial siphon and its laterals. The amount of weathering to which the surface of the segment had been subjected determined the features seen on the surface. In fig. 12 the pattern on the surface of the two uppermost whorls (x) is due to the fact that the weathering has extended for some distance inwards from the outer ends of the branches of the first order which are therefore seen in transverse section (*cf.* fig. 6). In the next three whorls (fig. 12, y), three or more darker patches are seen superposed on the end of each first-order branch (*cf.* figs. 2, 3). These represent the lumen of the second-order branches, the lighter network representing the calcareous deposit on the extremity of the first-order branch round the bases of the second-order branches.

Below this zone the hexagonal outlines of the first-order branches are lost to view, and the finer meshed network (z) which is seen represents the calcareous deposit between the second-order branches the lumena of which are presented by the slight depressions (*cf.* fig. 1). The organic calcium deposit is apparently more resistant to weathering than the filling material. The number of second-order branches from each first-order branch seems to vary from 2 to 7 in the specimens. In fig. 11 is seen a first-order branch rather shorter than usual, with the basal calcified portions of two second-order branches surmounting it. It has not been possible to distinguish with any certainty the presence of sporangia in this Indian specimen; occasionally, however, there are suggestions that the first-order branches functioned as sporangia, as in *Triploporella Fraasi* and *Remesi*. In fig. 9 there is a gap at (a) where three branches have not been preserved. There are also indications of small spherical bodies at the base of one. It is possible that the end portion of the wall of the sporangium was not calcified and hence the sporangium was not preserved. Other examples of the absence of certain members of a whorl of first-order branches of the siphon have been observed (fig. 4, h).

Relationship of the Alga.

In general habit *Triploporella ranikotensis* must have resembled *Coralliodendron* (*Ovulites*) *margaritula* Lamarck sp. and it is to be remarked that they are both of Eocene age. However, on examination of the relation of the lateral branches to the axial siphon in the segments of *Triploporella ranikotensis* it is seen that it is different from any plant described under the name of *Coralliodendron* or

Ovulites and that the forms with which it most closely agrees are those found in the *Dasycladaceæ*. On the whole the shapes of the first-order branches are very like those of *Triploporella*, and the arrangement of the second-order branches is also similar to what is found in that group. Among the large number of forms elegantly illustrated and described by Pia[1] there are a few genera in other groups than the *Triploporelleæ* (Olt.) in which the first-order branches are of this shape; *e.g.*, *Goniolina geometrica* Roem. sp., which Pia groups with *Triploporella* in the *Triploporellineæ*, and *Petrascula*.

It must be noticed tooth at in *Cymopolia* (*Bornetelleæ*) the thallus had a jointed structure, so that in this respect we have another point of contact with that group. As regards the structure of the branches of the first-order and the number of the branches of the second-order our species certainly resembles *Triploporella* (*T. Fraasi* and *T. Remesi*) very closely.

It resembles *T. Remesi* Stein. most closely in the number and arrangement of its second-order branches and *T. Fraasi* Stein. as regards the shape of its first-order branches.

The dimensional relationships between the three species, and one variety, of *Triploporella* which have been described are tabulated below :—

TRIPLOPORELLA.

Species.	*T. Remesi*, Stein.	*T. Fraasi*, Stein.	*T. Fraasi*, var. *minor*, Stein.	*T. ranikotensis*, sp. nov.
Geological Age . .	Jurassic .	Cretaceous	Cretaceous	Tertiary.
Outside dimensions of segments				
(*a*) Length . . .	15 mm. .	15 mm. .		3·5—5·0 mm.
(*b*) Diameter . . .	7—8 μ .	4 μ .	1·5—2·5 μ	2—2·5 μ
(*c*) Number of 1st Ordinary branches per whorl.	60—70 .	34—56 .		15—20
(*d*) Thickness of 1st Ordinary branches.	0·3—0·5 mm.	0·3 mm. .	0·20—0·25 mm.	0·35—0·45 mm.
(*e*) Number of 2nd Ordinary branches per 1st order branch.	3—5 .	3 .		3—7

[1] Pia, 1920.

On arranging the species in order of antiquity it appears that there has been simplification of the vegetative portions of the plant, in particular in the number of first-order branches in a whorl. It must, however, be noted that this is what one would have expected if the size of the first-order branches remained the same and there were a reduction in the circumference of the segment. The constancy in size of the first-order branches is an interesting feature. It is suggested that this may be correlated with the fact that in *Triploporella Remesi* and *T. Fraasi*, as we know definitely, the first-order branches functioned as sporangia and as such might be expected to be more conservative as regards shape and size than purely vegetative organs.

DIAGNOSIS.

Triploporella ranikotensis, sp. nov.

Thallus probably articulate, segments ovoid to conical, in transverse section circular. The extremities of the segments are rounded. The broader, upper extremity has a large depression; the lower extremity a smaller depression. Average length: 5 mm. Diameter of transverse section at broadest part: 2—2·5 mm. The segments consist of a central axial siphon with closely packed whorls of first-order branch-siphons. The diameter of the axial siphon at any particular level is approximately one-third the diameter of the segment at that level. The first-order branches occur in whorls of 15—20 and are roughly cylindrical but are somewhat flattened at the sides by contact with one another. The spaces between these branches are filled with calcium carbonate secreted by the plant. There are depressions on the outside which represent the bases of second-order branches which arose, 3—7 in number, from the end of each first-order branch.

Locality.—Sind, India.

Horizon.—Ranikot Beds. Tertiary. (Eocene of Europe).

In conclusion, I take the opportunity of expressing my thanks to Prof. Seward of Cambridge who kindly entrusted to me the carrying out of this investigation and to Mr. Gupta who supplied very useful notes and photographs some of which have been used in this account.

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EXPLANATION OF PLATE.

Triploporella ranikotensis, sp. nov.

(Photos. 1, 3, 4, 5, 6 and 7 by B. B. Gupta. Photo. 2 and drawings 8, 9, 10, 11, 12 by J. Walton.) The original specimens are with the Geoloigcal Survey of India, Calcutta.

1. Photo. of a segment covered with the small depressions which correspond to the bases of the 2nd order branches. × 8.
2. Photo. of a segment, weathered a little deeper than that in fig. 1, showing the ends of the 1st order branches outlined faintly by lighter ridges seen clearly at (*b*). Above the middle the 2nd order branch depressions are seen in distinct groups (*c*) corresponding to the underlying 1st order branches. ×8.
3. Photo. of a differently shaped segment with much the same type of structure visible as at (*c*), fig. 2. × 8.
4. Photo. of a segment just above the middle; one of the 1st order branches has not been preserved and is represented by a hole (h). Basal depression, (*d*). × 8.
5. Photo. of larger end of a segment with a double apical depression. × 8.

6. Portion of a segment weathered deeper and showing the 1st order branches in section. × 8.
7. Photo of a longitudinal section of a segment median at the top, tangential at the base. × 8.
8. Drawing of a similar but accurately median section. × 16.
9. Drawing of a cross section of a segment in the state of that represented in fig. 6. (*a*) cavity formed by the non-preservation of three 1st order branches (sporangia ?). × 16.
10. Drawing of segment with tangential slice removed. The whorled arrangement of the 1st order branches is evident. × 16.
11. Drawing of a portion of segment sliced longitudinally and radially showing rather shorter 1st order branch with basal portions of two 2nd order branches. × 16.
12. Drawing of terminal portion of segment showing different stages of weathering. The region (*x*) corresponds to the state of weathering in fig. 6, (*y*) to that in fig. 2, and (*z*) to that in fig. 1. × 16.

FROTH FLOTATION OF INDIAN COALS. BY W. RANDALL, M.SC.

INTRODUCTION.

THE cleaning of coal by froth flotation is a development of the processes known to, and extensively used by, the metalliferous mining industry for some years. It has been successfully applied on a large scale in several countries. During the past two years many of the coals of India have been examined and I am now able to give an indication of the possibilities of applying froth flotation to the treatment of Indian coals.

The advisability of cleaning a coal depends upon the resultant balance between the value of the advantages to be gained by cleaning, and the cost of treatment. The fact that Indian coals have not yet been cleaned on a commercial scale is due, therefore, to one or more of the following reasons :—

(*a*) The coals are of sufficiently high grade for the purposes for which they are used.

(*b*) The nature of the coals does not allow of a useful amount of cleaning being done.

(*c*) The coals are cleanable, but the processes available hitherto have been found to be incapable of treating them successfully on a commercial scale.

Regarding (*a*), general interest in froth flotation is evidence that the development of a process for cleaning Indian coals is desirable. For special purposes, particularly those of the metallurgical industries, there is a demand for high class coals. The supplies of these are not unlimited, and unless coals of lower grades can be cleaned the present indiscriminate use of the unknown reserves of high grade coals is a serious matter. In addition to work on this very important aspect of coal-cleaning, attention has also been given to the possibility of improving the quality of what are now regarded as first class coals.

Referring to (*b*), it is widely known that a large proportion of the ash of most Indian coals is inherent or occurs as part of the coal substance. Some of the coals are practically homogeneous and are therefore not cleanable by any physical process.

On the other hand, many of the Indian coals are heterogeneous; and in these cases (*c*), the advisability of cleaning depends on the result of a balance between advantages and costs. The former are determined by the purposes for which the coal is suitable, and by the extent to which it can be cleaned in practice. These factors depend fundamentally on the constitution of the coal.

In testing samples of coal from various sources it has been found that the constitution of a parcel varies with the following factors:-

(*a*) Its origin, *i.e.* the field, district, and seam.
(*b*) Whether it is representative of the whole or only part of the seam.
(*c*) Whether it is "run-of-mine," or a "screen" product.
(*d*) Whether it has been picked or washed.

Hence the history of any sample submitted for tests is very important. Attention has been given only to samples taken by responsible persons. Samples of run-of mine coal have been obtained directly from working faces. Data concerning the sections and the rejection of shale or other bands have been noted. Samples of screen products have been obtained by special tests on tramloads of coal cut as samples from the coal faces.

CONSTITUTION OF INDIAN COALS.

Most of the Indian coals occur in thick seams, and the proportion of shale bands in the seams is usually very small. The shale bands found in the seams are rarely less than 2 inches in thickness and are therefore easily pickable. Hence the proportion of the ash of picked run-of-mine coal due to shale is in most cases negligible. The bulk of the ash is due to the inferior constituents of the coal itself.

M. Stopes[1] in an important paper, has described the constituents of the bituminous coal of Hamstead Colliery, near Birmingham, England. The publication of this paper did much in directing research on coal towards the investigation of its constituents rather

[1] On the Four Visible Ingredients in Banded Bituminous Coal. Studies in the Composition of Coal, No. 1. Dr. Marie Stopes. *Proc. Roy Soc. Lond*, Series B, Vol. XC, p. 470.

than towards that of the coal as a whole. The following is an extract from the publication :—

" Essentially the present contribution to the subject consists in the explicit recognition not of mere " dull " and " bright " bands, but of *four* distinctive and visibly differing portions forming the mass of an ordinary bituminous coal ; and the demonstration of the fact that these four portions can be recognised and separated from each other both macroscopically, by hand, and microscopically in thin sections ; and that, further, these four portions react so differently to certain simple chemical treatments as to indicate that their chemical molecules should be substantially different from each other. . . .

These four distinguishable ingredients, all of which, in varying quantities, are to be found in most ordinary bituminous coals, I name provisionally as follows :—

(I) Fusain.—The equivalent of " mother of coal," " mineral charcoal " etc., of various authors.

(II) Durain.—The equivalent of " dull " hard coal of various authors, the " Mattkohle " of Germans, etc.

(III) Clarain. } —Together the equivalent of " bright " or glance coal of various authors, the " Glanzkohle " of Germans. Sometimes the " bright " coal of an author seems to be the vitrain only.

(IV) Vitrain. —(Conchoidal fracture, brilliant in appearance.)

. . . .

The appearances of the four ingredients with the naked eye i.e. *their macroscopic appearances.*

Fusain occurs chiefly as patches and wedges, somewhat flattened parallel to the bedding plane, and often with rather square-cut ends. It consists of powdery, readily detachable, somewhat fibrous strands. The orientation of the fibrous structure tends to be lengthways in relation to each wedge, and the various wedges on a bedding plane lie at various angles to each other, so that in any given light some appear dull and some glisten according to the direction the light catches the fibres.

The fusain is readily separated from the rest of the coal (which is all firmer than it in texture) by delicate scraping with a blunt knife, when the short, fibrous strands and small, sharp-pointed, irregular fragments fall freely on to a paper laid so as to catch them.

Where, as may happen, a thick wedge of fusain is contiguous with a true vitrain band, the fusain may appear as though embedded or sunk in the vitrain. . . . The fusain can then be entirely scooped out, leaving exposed on the vitrain the hollow in which it lay, the surface of this vitrain hollow being curved and smooth. The contact surfaces of both clarain and durain with fusain, however, are much less precise, and an impression of the fibres of the fusain is generally left on the harder durain or clarain after all the friable detachable fibres of the fusain have been removed.

Durain occurs generally as bands of very variable thickness, and when seen in a face at right angles to the bedding plane, they appear parallel to it, though, if traced far enough, they generally reveal their ultimately lenticular shape. Wider bands of comparatively pure durain are less common, but bands, 2, 3, or more inches thick are often sharply differentiated from the adjacent streaky brigh clarain.

Durain is hard, with a close, firm texture, which appears rather granular even to the naked eye. However straight the break across it, the broken face is never truly smooth, but, if looked at closely, always has a finely lumpy or matte surface. . . . Generally, even in the dullest of durain bands a few (or many) flecks or hair-like streaks of bright coal are to be seen.

The intercalation of narrow bands of durain and clarain tends to increase at the junction of the broad "dull" and the broad "bright" bands, so that there is no large surface of contact between them which is sharp cut and well defined, even the purest clarain and the purest durain tend to have ravelled edges, which interlock. . . .

Clarain occurs generally as bands of very variable thickness, and when seen in a face at right angles to the bedding plane they appear parallel to it. Like durain bands, they are ultimately widely extended lenticular masses. Clarain, even when considerably streaked with durain, has a definite and smooth surface when broken at right angles to the bedding plane, and these faces have a pronounced gloss or shine. This surface lustre is seen to be inherently banded, as well as to have bands of fine durain intercalated between its own bands. . . .

Vitrain occurs as definite rather narrow bands, in some instances straighter and flatter than the other bands of coal, and in some instances more obviously lenticular. True brilliant vitrain bands are often markedly uniform in thickness for considerable distances, and are commonly from about 2 mm. to 3 or 4 mm. up to 6 or 8 mm. thick, but are very seldom much more than 8 to 10 mm. thick. The limiting layer between the vitrain and the contiguous clarain or durain is generally sharply marked and is often clean-cut definite surface. . . . A single brilliant band does not exhibit the fine banding detectable even in the brightest of clarain, but is a coherent and uniform whole, brilliantly glossy, indeed vitreous, in its texture. The compact vitreous band may split up readily in the fingers to small cube-like segments, but more generally they break irregularly when forced, as with a pen-knife point, when the curved irregular faces have well-marked conchoidal fracture. . . . As was mentioned in connection with fusain, the contact—surfaces of vitrain with the other ingredients of coal tend generally to be well defined with a firm, hard and glassy face."

Examination of a Jharia coal shows that it contains the constituents defined by M. Stopes. The proportion of fusain is usually small, and, like that of the English coal, its analysis varies. Approximate ash contents, at various definite specific gravities, of the more important constituents, are as follows :—

Specific Gravity.	Ash per cent.	Constituent
1·26	1	Vitrain.
1·30	5	Clarain.
1·35	10	Clarain.
1·40	15	Clarain.
1·45	20	Durain.
1·50	25	Durain.
1·60	40	Durain

The proportions, and differences in physical properties, of the constituents determine the extent to which the coal can be cleaned by a perfect practical process. Tests at various meshes show that to set free the constituent bands of Indian coals it is necessary to crush the coals to about $\frac{1}{20}$ inch.

Since ash percentage and specific gravity rise together, separation by heavy liquid gives a perfect separation suitable for use in a laboratory examination of the constitution of samples. This will be recognised as the well known "float and sink" test, but to avoid any possibility of confusion with froth flotation I prefer to use the term "separation by heavy liquid," or "heavy liquid separation."

CLEANING PROCESSES.

It will be seen from the above remarks that any cleaning process, to be effective, must be capable of separating the constituents of the coal after it has been crushed to about $\frac{1}{20}$ inch. The factors available for utilization are :—

(*a*) Differences in surface properties of the constituents.

(*b*) Differences in specific gravity of the constituents.

(*c*) Differences in any other physical properties of the constituents.

The possibilities of successfully applying the known coal cleaning processes may now be considered.

GRAVITY WASHERS.

The fact that there is no marked difference in specific gravity of the constituents of Indian coals, and the necessity for fine crushing, are reasons sufficient to explain why no gravity washer has been able to treat these coals on a commercial scale.

HEAVY LIQUID SEPARATION.

This gives a perfect separation which is of value in the laboratory examination of samples, but the process is too expensive to allow of its being applied on a large scale.

TRENT PROCESS.

In the Trent process [1] the coal, ground very fine, preferably to —200 mesh, is mixed with water, and a hydrocarbon oil added at the rate of about 33 per cent. of the weight of the coal. The oil and coal form an agglomerate which separates from the water, while the free ash-forming constituents of the coal remain suspended in the water. It is necessary to add enough oil to fill all the voids between the coal particles, thus substantially excluding the water; the agglomerate may, however, contain 10 per cent. of water. The agglomerate is a plastic mass which could not be used as a substitute for hard fuel. It is claimed, however, that the oil can be distilled from the agglomerate, leaving the pure coal behind. The large quantity of oil required, and the expense of recovering this by distillation, are serious handicaps to this process. So far as I am aware, the process cannot be used to separate the vitrain and clarain from the inferior durain.

The conclusion seems justifiable, therefore, that froth flotation is the only one of the known coal-cleaning processes capable of application on a commercial scale to the treatment of Indian coals.

FROTH FLOTATION.

The determining factor in the operation of this process is differences in surface properties. The separation is independent of differences in specific gravity. Particles of coal of all sizes up to about $\frac{1}{8}$ inch can be "floated," and the fact that Indian coals must be crushed to $\frac{1}{20}$ inch to set free their constituent bands does not handicap the efficiency of the process. Hence the possibility of applying froth flotation to the treatment of Indian coals is determined by their constitution, the differences in their surface properties, and financial considerations.

[1] Trent Patents (British) {183,430; 151,236; 159,497}

The process, and the operation of a plant, may be briefly described as follows :—

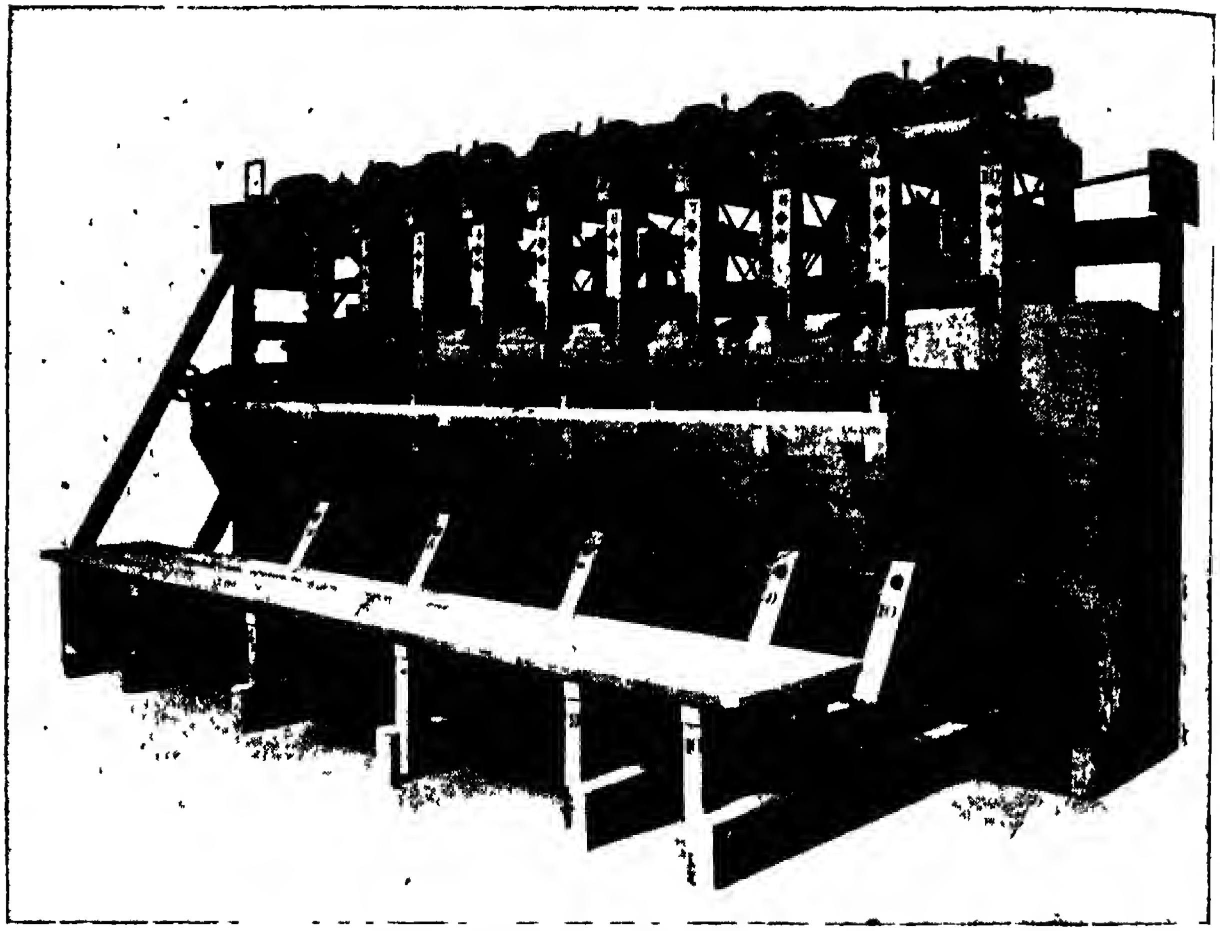

FIG. 1.—GENERAL VIEW OF A FROTH FLOTATION PLANT FOR THE SEPARATION OF COAL.

The coal, along with about four times its weight of water, sufficient to form a mobile pulp, is fed continuously into the first mixing box of the p'ant. By the eddition of a small proportion of a frothing reagent the air entrained by the agitation produced by an impellor forms a multitude of minute air bubbles in the pulp. The pure coal particles, owing to their surface properties, are not wetted by water, and air bubbles become attached to them. The aerated pulp passes through a slot into the first froth box, where, the pulp coming to a state of comparative rest, the air bubbles with their loads of coal particles rise to the surface and form a dense coherent forth which is removed by the paddles. The remainder of the pulp passes from the bottom of the first froth box, through a connecting pipe, to the second mixing box, where it is again agitated and aerated, after which it passes to the second froth box. A commercial scale plant consists of about eight mixing boxes and corresponding eight froth boxes arranged alternately in series. The circulation of the pulp is illustrated diagrammatically in figure 2.

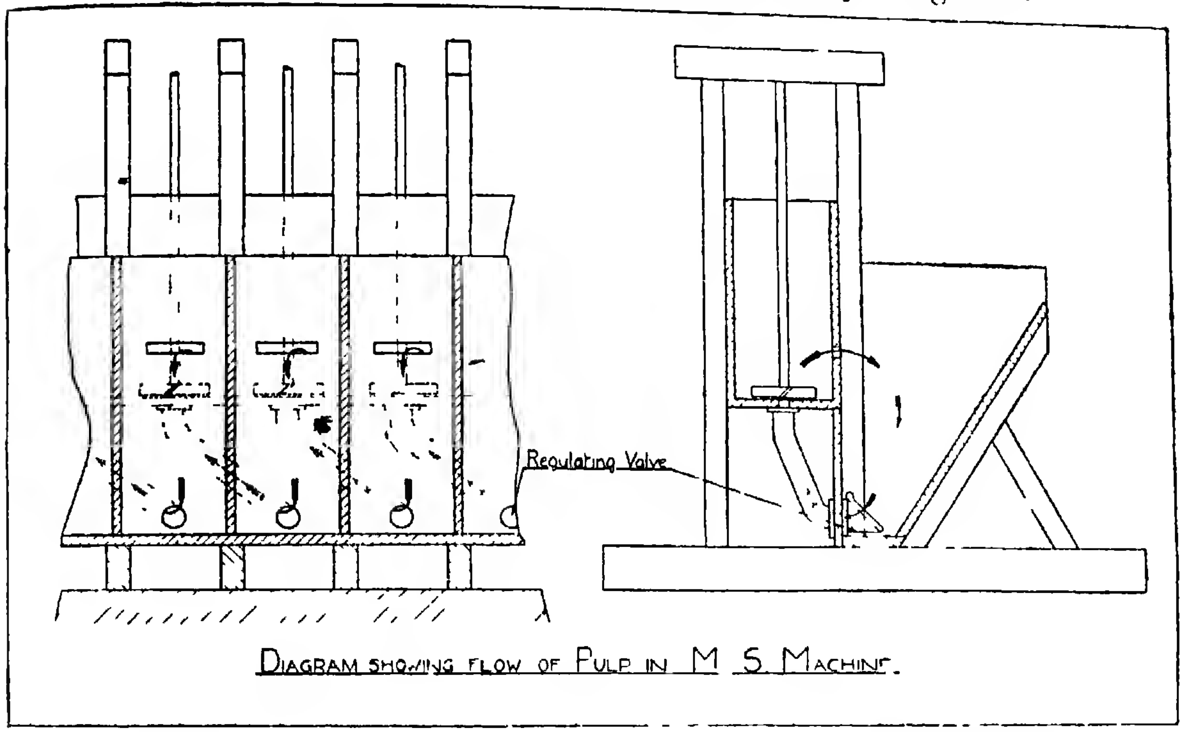

FIG. 2.—SHOWING OPERATING DETAILS OF THE FROTH FLOTATION PLANT FOR THE SEPARATION OF COAL.

The first froth boxes recover the highest grade coal, and the later boxes the poorer grade material. The remainder is discharged from the bottom of the last froth box. Hence, by a suitable arrangement of receiving launders, one or more products may be made as follows :—

1. If the froths from all eight boxes are received by one launder, two products will be made :—
   (*a*) Clean product of high grade.
   (*b*) Remainder of no value.
2. If the froths from the first boxes are received by one launder, and the froths from the later boxes by another launder, three products will be made :—
   (*a*) Clean product of high grade.
   (*b*) Middle product.
   (*c*) Remainder of no value.

The clean coal froth, as removed from the flotation plant, contains about equal weights of coal and water. A method of dewatering this froth has been developed by Messrs. Minerals Separation, Limited, and, as it has been successfully applied on a large scale in England and France, the patentees have kindly supplied the following notes:

"In relation to the dewatering of coal concentrates, the method to be recommended depends on whether it is desirable to make the concentrates into durable briquettes to be subsequently used as fuel, or merely to prepare the concentrates for subsequent coking. In any case, the treatment depends on the fact that, when the coal particles have been superficially coated with a thin layer of tar or the like, their surfaces are no longer wettable by water. As a consequence, the water entangled amongst the particles can be readily pressed out, leaving a product which is relatively free from water.

In the briquetting process, soft pitch in a molten condition, or a molten mixture of tar and hard pitch, is sprayed into the concentrate pulp, which may contain equal weights of coal and water, the pulp being agitated meanwhile. As a consequence the particles become superficially coated with a layer of binder **and**, on raising the temperature of the pulp to about 60°C.-100°C., an intense flocculation is produced. If the flocculated pulp is pressed in a mould provided with means for the water to escape, a hard durable briquette, containing less than 10 per cent. of water, is produced. If the briquette is allowed to stand for a few hours, the content of water drops to 4-5 per cent.

If the coal concentrates are to be dewatered in preparation for subsequent coking, the coating of the coal particles and then flocculation can be effected in cold circuit by the addition of tar, preferably in the form of an emulsion. The flocculated coal can be dried by pressing in moulds or by drainage on a porous belt; or the water can be pressed out between two porous belts which run between rollers."

For laboratory flotation tests, results of which are given later in this paper, a machine consisting of one mixing box and one froth box, and which is therefore discontinuous in operation, is used. The conditions are essentially similar to those of the commercial plant. Results approximating to those of the perfect separation have been obtained on many Indian coals, and equally good results could, presumably, be obtained in large scale operation.

The possibility of commercially cleaning Indian coals is not limited therefore, as hitherto, by practical difficulties, but by the financial aspect of the matter. The scope of froth flotation is determined, not by its ultimate capabilities, but by the constitution of the coals available for treatment, and by the effects of supply and demand.

CLEANING OF INDIAN COALS FOR COKING.

The nature of the coal, whether coking or non-coking, determines the uses for which it is suitable. The purposes for which the coal can be used determine the advantages to be gained by cleaning. The treatment of coal for coking presents the greatest advantages.

Coking coals are those of which the better constituents are strongly coking, and the inferior constituents are weakly coking or non-coking. In the first-class coking coals the proportions of the constituents are such that the coal gives a satisfactory coke. In the second class coking coals the proportions of the constituents are such that the coal gives a weak coke of high ash content. Some of the more inferior coking coals are of such quality that they may be regarded as commercially non-coking. The difference is merely one of a difference in the proportions of the constituents. Flotation can concentrate the better constituents, vitrain and clarain, and eliminate the higher-ash non-coking ones, durain and fusain. Hence the proportion of clean product, of a quality suitable for coking, which can be separated, depends only on the quality of the seam and its heterogeneous nature, *i.e.* its cleanability. Flotation clean products from second class coking coals have given cokes of excellent quality, and one of the largest iron and steel works in India has expressed the opinion that they are as good as can be desired.

Flotation, or any other process, cannot separate a coking product. from a coal which does not contain any coking constituents India has large reserves of sub-bituminous non-coking coals. Their high moisture contents are an indication of the fact that they are constituted of vegetable products much less altered than is the case in the coking coals. The constituents of these sub-bituminous coals are all non-coking, and for this reason the coals are incapable of being cleaned to yield coking products.

CLEANING OF INDIAN COALS FOR BRIQUETTING.

In general the most inferior constituents of the Indian coals, although of fairly high ash content, have calorific values of 5,000 to 7,000 B. Th. U. For this reason cleaning of the Indian coals cannot appreciably increase their calorific values, and, unless the conditions are exceptionally favourable, cleaning for briquetting will not be profitable.

RESULTS OF FLOTATION TESTS.

The better constituents are floated first, and in the later boxes of the plant the froths are of increasingly inferior qualities. Hence the percentage of clean product from any particular coal determines the quality of the product. Results are set out to show this variation, and the quality of the remainder is also indicated. For the sake of simplicity only two products are given, but the question of whether two or three products should be made must be decided in particular cases when the specific requirements can be taken into consideration.

The coals tested may be divided into five classes :

I. Coking coals of Jharia, Bokaro and Barakar.
II. Non-coking coals of the Raniganj district.
III. Coking Tertiary coals of Assam.
IV. Non-coking coals of the Central Provinces, Bihar and Orissa.
V. Non-coking Tertiary coals of the Punjab and the North-West Frontier Province.

Coals which have not yet been tested will probably fall into one of these five classes.

I. COKING COALS OF JHARIA, BOKARO AND BARAKAR.

These are coking coals from Jharia, Giridih, Bokaro, and the Barakar area of the Raniganj field.

Typical analyses are as follows :—

Ash	15	20	25 per cent.
Moisture	1·0	0·8	0·6 ,,
Volatile Matter	24	23	22 ,,
Fixed Carbon	60	56	52 ,,

JHARIA.

Results obtained from face samples, representative of run-of mine coal, are set out below :—

Ref. No. 236. "17 Seam," Jharia area. Ash 12·7 per cent.

Clean product .	Weight	60	70	75	80	85	90 per cent
	Ash .	7·8	8·4	8·8	9·2	9·7	10·2 ,,
Remainder .	Weight .	40	30	25	20	15	10 per cent.
	Ash .	20·1	22·7	24·4	26·7	29·6	35·2 ,,

Ref. No. 1067. "15 Seam," Jharia area. Ash 13·6 per cent.

Clean product	Weight .	60	70	75	80	85	90 per cent.
	Ash .	6·6	7·3	7·6	8·0	8·4	9·2 ,,
Remainder	Weight .	40	30	25	20	15	10 per cent.
	Ash .	24·1	28·3	31·6	36·0	43·3	53·2 ,,

Ref. No. 601. "15 Seam," Jharia area. Ash 14·5 per cent.

Clean product	Weight .	60	70	75	80	85 per cent.
	Ash .	9·7	10·4	10·8	11·3	11·6 ,,
Remainder .	Weight .	40	30	25	20	15 per cent.
	Ash .	21·7	24·1	26·0	27·3	31·0 ,,

Ref. No. 237. "18 Seam," Jharia area. Ash 16·3 per cent.

Clean product	Weight .	60	70	75	80	85 per cent
	Ash .	9·4	10·5	11·1	11·6	12·2 ,,
Remainder .	Weight .	40	30	25	20	15 per cent.
	Ash .	26·7	29·8	31·8	35·0	39·4 ,,

Ref. No. 438. "14 Seam," Jharia area. Ash 16·6 per cent.

Clean product	Weight .	60	70	75	80	85 per cent
	Ash .	10·1	10·7	11·1	11·5	12·1 ,,
Remainder .	Weight .	40	30	25	20	15 per cent.
	Ash .	26·3	30·4	33·1	37·0	42·0 ,,

Ref. No. 437. "12 Seam," Sijua area. Ash 17·0 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	10·8	11·5	11·9	12·4	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	26·3	29·8	32·3	35·4	,,

Ref. No. 646. "16 Seam," Jharia area. Ash 17·9 per cent.

Clean product	Weight	60	70	75	80	per cent.
	Ash .	10·2	11·7	12·6	13·4	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	30·0	32·7	33·8	35·4	,,

Ref. No. 1049. "13 Seam," Jharia area. Ash 18·0 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	10·5	11·5	12·0	12·7	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	29·3	33·2	36·0	39·2	,,

Ref. No. 1068. "14 Seam," Jharia area. Ash 18·2 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	11·6	12·6	13·2	13·8	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	28·1	31·3	33·2	35·8	,,

Ref. No. 604. "11" and "12 Seam," Jharia area. Ash 19·0 per cent.

Clean product	Weight	60	70	75	80	per cent.
	Ash	12·3	13·2	13·7	14·3	,,
Remainder	Weight	40	30	25	20	per cent.
	Ash	29·1	32·5	35·0	37·8	,,

Ref. No. 1045. "13 Seam," Sijua area. Ash 19·4 per cent.

Clean product	Weight	60	70	75	80	per cent.
	Ash	12·3	13·3	13·8	14·5	,,
Remainder	Weight	40	30	25	20	per cent.
	Ash	30·1	33·6	36·2	39·0	,,

Ref. No. 430. "18 Seam," Sijua area. Ash 19·9 per cent.

Clean product	Weight	60	70	75	80	per cent.
	Ash	13·1	11·5	15·2	15·9	,,
Remainder	Weight	40	30	25	20	per cent.
	Ash	30·1	32·5	34·0	35·9	,,

Ref. No. 603. "13 Seam," Jharia area. Ash 20·1 per cent

Clean product	Weight	60	70	75	80	per cent.
	Ash	11·9	12·8	13·3	13·9	,,
Remainder	Weight	40	30	25	20	per cent.
	Ash	32·4	37·1	40·5	45·0	,,

Ref. No. 571. "16 Seam," Sijua area. Ash 21·1 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	14·3	15·6	16·3	17·2	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	31·3	33·9	35·6	36·8	,,

Ref. No. 605. "10 Seam," Jharia area. Ash 21·8 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	16·3	17·3	17·9	18·4	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	30·1	32·3	33·5	35·4	,,

Ref. No. 552. "16 Seam," Jharia area. Ash 22·4 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	11·8	13·7	14·7	15·9	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	38·3	42·8	45·5	48·4	,,

Ref. No. 1950. "14 Seam," Sijua area. Ash 23·4 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	15·5	16·8	17·4	18·0	,,
Remainder .	Weight	40	30	25	20	per cent.
	Ash .	35·3	38·8	41·3	45·0	,,

Ref. No. 1048. "*15 Seam,*" *bottom, Sijua area. Ash 28·4 per cent.*

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	20·2	21·9	22·6	23·4	..
Remainder	Weight .	40	30		20	per cent.
	Ash .	40·7	43·6	45·8	48·4	..

The above results are from face samples, representative of run-of-mine coal, and are arranged in the order of increasing ash-content of the coal. Some seams are more homogeneous, and, therefore, less amenable to cleaning than others. Run-of-mine coal of many seams, of quality up to about 20 per cent. ash, is capable of being cleaned to give a large product of a quality suitable for coking and a correspondingly small remainder of practically no value. Run-of-mine coals of more than 20 per cent. ash, because of their inferior constitution, are generally incapable of giving a large percentage of a product suitable for coking, and in these cases preferential crushing of their better constituents is of great importance.

PREFERENTIAL CRUSHING OF VITRAIN AND CLARAIN.

During mining and subsequent handling, coal breaks along bedding blanes, along cleavage planes, and other directions of fracture. The hetter constituents, vitrain and clarain, are more friable than the parder and inferior durain. Vitrain is also frequently intersected by joints. For these reasons nearly all the fractures parallel to the bedding planes of the coal are through bands of vitrain. Hence the slack of run-of-mine coal contains a larger percentage of the better constituents than does normal run-of-mine coal from the same seam, and for this reason it is more amenable to cleaning. This is shown by the following results of flotation tests.

Ref. No. 3. "*14 Seam,*" *Jharia area. Run-of-mine. Ash 15·6 per cent*

Clean product	Weight .	60	70	80	per cent.
	Ash .	9·8	10·7	11·7	,,
Remainder	Weight .	40	30	20	per cent.
	Ash .	24·3	27·0	31·2	,,

Ref. No. 213. "14 Seam," same colliery as above —½ inch Slack. Ash 13·1 per cent.

Clean product .	Weight .	60	70	80	90	per cent.
	Ash .	7·4	8·2	9·3	10·7	,,
Remainder . .	Weight .	40	30	20	10	per cent.
	Ash .	21·6	24·6	28·3	34·7	,,

Ref. No. 6. "17 Seam," Jharia area. Run-of-mine. Ash 18·5 per cent.

Clean product .	Weight .	60	70	80	per cent.
	Ash .	12·4	13·2	14·0	,,
Remainder . .	Weight .	40	30	20	per cent.
	Ash .	27·6	30·9	36·5	,,

Ref. No. 218. "17 Seam," same colliery as above —½ inch Slack. Ash 16·1 per cent.

Clean product .	Weight .	60	70	80	per cent.
	Ash .	7·5	8·4	10·0	,,
Remainder . .	Weight .	40	30	20	per cent.
	Ash .	29·0	34·1	40·0	,,

Ref. No. 821. "16 Seam," Sijua area. Face sample. Ash 18·7 per cent.

Clean product	Weight .	60	70	75	80	per cent.
	Ash .	10·5	12·1	12·9	13·7	,,
Remainder .	Weight .	40	30	25	20	per cent.
	Ash .	31·0	34·1	36·0	38·7	,,

Ref. No. 820. "16 Seam," same colliery as above —½ inch Slack. Ash 14·5 per cent.

Clean product	Weight .	60	70	75	80	85	per cent
	Ash .	7·0	7·9	8·4	9·0	9·7	,,
Remainder .	Weight .	40	30	25	20	15	per cent.
	Ash .	25·8	29·9	32·8	36·5	41·7	,,

These tests show that – ½ inch slack, *i.e.*, the portion of the run-of-mine coal which will pass through a screen of ½ inch aperture, is more amenable to cleaning than the aggregate run-of-mine coal from the same seam.

From the above results it will be seen that the practice of using slack for brick burning or as boiler fuel and, frequently at the same colliery, of crushing run-of-mine coal for coking is wrong. Slack should be cleaned for coking.

This preferential crushing of the better constituents can be carried a stage further. The —½ inch slack produced during mining may be about 10 to 15 per cent. of the coal mined. Coals which are not sufficiently amenable to cleaning to be commercially cleanable as run-of-mine coal may be utilized in the following manner. Further preferential crushing may be obtained by breaking the run-of-mine coal to about 1½ inch in a toothed roll type of crusher. The crushed coal, screened on say ½ inch, will give rubble (—1½ inch, + ½ inch) suitable for boiler firing, and "fines" (—½ inch) which may be cleaned for coking. Results obtained in this manner from a tramload of coal cut as a face sample are given below :

Ref. No. 552. "16 Seam," Jharia area. Run-of-mine, unpicked. Ash 22·4 per cent.

Crushed to $-1\frac{1}{2}$ inch, screened on 1 inch aperture screen, this gave the following products :—

		Weight per cent.	Ash per cent
Rubble, hand-picked .	Clean $-1\frac{1}{2}$ inch, + 1 inch	37·2	21·1
	Reject $-1\frac{1}{2}$ inch, + 1 inch	5·2	57·8
Fines (Ref. No. 551)	-1 inch	57·6	20·1

Crushed to $-1\frac{1}{2}$ inch, screened on $\frac{1}{2}$ inch aperture screen, the same run-of-mine coal, Ref. No. 552, gave the following products :

		Weight per cent.	Ash per cent.
Rubble, hand-picked .	Clean $-1\frac{1}{2}$ inch + $\frac{1}{2}$ inch	57·3	21·4
	Reject $-1\frac{1}{2}$ inch + 1 inch	5·2	57·8
Fines (Ref. No. 550)	$-\frac{1}{2}$ inch	37·5	19·2

It will be noted that hand-picking of material smaller than 1 inch has not been attempted, and that the analysis of the material picked out, ash 57·8 per cent., is an indication of the fact that there is sufficient difference in the appearance of the clean rubble and the rejected pieces to allow of picking by unskilled labour.

The word "fines" is used in the special sense of meaning the portion of the crushed run-of-mine coal which will pass through a screen of the aperture indicated. It will be noted on page 236 that a similar product from uncrushed run-of-mine coal is called "slack". Hence, fines is made up of slack *plus* small material produced by mechanical crushing subsequent to mining.

Tests have been done on both 1 inch and $\frac{1}{2}$ inch fines for comparison. The greater cleanability of fines is shown by the following results of tests :—

Ref. No. 552. "16 Seam," Jharia area. Run-of-mine, unpicked. Ash 22·4 per cent.

Clean product .	Weight .	60	70	75	80	per cent.
	Ash .	11·8	13·7	14·7	15·9	,,
Remainder . .	Weight .	40	30	25	20	per cent.
	Ash .	38·3	42·8	45·5	48·4	,,

Ref. No. 551. −1 inch Fines. *See p. 238.* *Ash 20·1 per cent.*

Clean product	Weight .	60	70	75	80	85 per cent.
	Ash .	10·2	11·8	12·7	13·8	14·9 ,,
Remainder .	Weight .	40	30	25	20	15 per cent.
	Ash .	34·9	39·5	42·3	45·3	49·3 ,,

Ref. No. 550. −½ inch Fines. *See p. 238.* *Ash 19·2 per cent.*

Clean product	Weight .	60	70	75	80	85 per cent.
	Ash .	9·5	11·0	11·7	12·5	13·2 ,,
Remainder .	Weight .	40	30	25	20	15 per cent.
	Ash .	33·8	38·4	41·7	46·0	53·2 ,,

These results show that a seam, which may not be commercially cleanable as run-of-mine coal, may be crushed to give rubble for boiler-firing or for general purposes, and fines cleanable for coking. The tests done are sufficient to prove the applicability of the suggestion. Further details, such as the amount of crushing to be done and the mesh of the screen to be used for separating the rubble and fines, may be determined by further tests in special cases, when the particular conditions and the financial details of the proposition can be taken into account

GIRIDIH.

As Giridih is a small field of good quality coal, samples have not been tested.

BOKARO.

Kargali Seam.

The Kargali seam is a coking coal, which is capable of being cleaned as shown by the following results :

Ref. No. 356. Kargali Seam, Face sample. Ash 22·3 per cent.

Clean product	Weight .	50	60	70	per cent.
	Ash .	14·4	15·8	17·0	,,
Remainder	Weight .	50	40	30	per cent.
	Ash .	30·2	32·1	34·7	,,

Ref. No. 402. Kargali Seam (same colliery as above) —½ inch Slack. Ash 20·6 per cent.

Clean product	Weight .	50	60	70	75	80	85	per cent.
	Ash .	9·6	10·5	11·7	12·5	13·2	14·1	,,
Remainder	Weight .	50	40	30	25	20	15	per cent.
	Ash .	31·6	35·8	41·4	45·0	50·2	57·3	,,

Ref. No. 815. Kargali Seam, Top Section. Face sample. Ash 20·9 per cent.

Clean product	Weight .	50	60	70	75	80	per cent.
	Ash .	11·0	12·4	14·0	14·8	15·5	,,
Remainder .	Weight .	50	40	30	25	20	per cent.
	Ash .	30·8	33·7	37·0	39·2	42·5	,,

Ref. No. 811. Kargali Seam, Top Section. —½ inch Slack. Ash 17·1 per cent.

Clean product	Weight .	50	60	70	75	80	85	per cent.
	Ash .	7·7	8·6	9·6	10·3	11·0	11·7	,,
Remainder	Weight .	50	40	30	25	20	15	per cent.
	Ash .	26·5	29·8	34·6	37·5	41·5	47·0	,,

Ref. No. 817. Kargali Seam, Bottom Section. Face sample. Ash 25·2 per cent.

Clean product	Weight .	50	60	70	75	80 per cent.
	Ash .	16·5	17·9	19·3	20·0	20·7 ,,
Remainder .	Weight .	50	40	30	25	20 per cent.
	Ash .	33·9	36·2	39·0	40 8	43 2 ,,

Ref. No. 812. Kargali Seam, Bottom Section. – ½ inch Slack. Ash 22·8 per cent.

Clean product	Weight .	50	60	70	75	80 per cent.
	Ash .	11·2	12·7	14·3	15·1	16 0 ,,
Remainder .	Weight .	50	40	30	25	20 per cent.
	Ash .	34·4	38·0	42·6	45·8	50·0 ,,

The above results show that slack from the Kargali seam is amenable to cleaning. The clean product from the Kargali coal has been made into coke of excellent quality.

Bermo Seam.

The coal of this seam is very homogeneous. Heavy liquid separation shows that it is incapable of being cleaned.

BARAKAR AREA OF THE RANIGANJ FIELD.

The coals obtained from the neighbourhood of Barakar in the Raniganj field, have a moisture content of less than 1·5 per cent. and are coking. Results of tests on face samples are given below :—

Ref. No. 257. Laikdih Seam. Ash 14·0 per cent.

Clean product	Weight .	60	70	75	80	85 per cent.
	Ash .	10·4	11·1	11·5	11 8	12 2 ,,
Remainder .	Weight .	40	30	25	20	15 per cent.
	Ash .	19·4	20·7	21·5	22 8	24·1 ,,

Ref. No. 258. Ramnagar Seam. Ash 13·6 per cent.

Clean product	Weight	60	70	75	80	85 per cent.
	Ash	7·6	8·6	9·2	9·8	10·5 „
Remainder	Weight	40	30	25	20	15 per cent.
	Ash	22·6	25·3	26·8	28·8	31·1 „

Ref. No. 260. Ramnagar Seam. Ash 16·7 per cent.

Clean product	Weight	60	70	75	80 per cent.
	Ash	10·8	12·0	12·5	13·1 „
Remainder	Weight	40	30	25	20 per cent.
	Ash	25·6	27·7	29·3	31·1 „

II. NON-COKING COALS OF THE RANIGANJ FIELD.

A typical analysis of coal from the Barakar stage of the Damuda series in the Raniganj field is :—

Ash . .	17 per cent.
Moisture .	4 „
Volatile Matter	33 „
Fixed Carbon	46 „

Very few samples from these beds have been tested. The coals which have been examined are non-coking and are incapable of yielding coking products. On account of the fairly high calorific values of the inferior constituents of the coals, cleaning for general purposes is not likely to be profitable.

III. COKING TERTIARY COALS OF ASSAM.

The Tertiary coals of Assam are coking. They have very low ash contents, and their chief impurity is sulphur. A typical analysis of the coals is as follows :—

Ash .	2 per cent.
Moisture .	1 „
Volatile Matter	44 „
Fixed Carbon	53 „
	100

Sulphur 2 per cent.

The occurrence of the sulphur has been investigated. It is found to be fairly evenly distributed throughout the coal substance. This is shown by the following results of heavy liquid separation :—

Ref. No. 401.

Specific Gravity of liquid on which it floats.	Specific Gravity of liquid in which it sinks.	DIRECT.			CUMULATIVE.		
		Weight, per cent.	Ash, per cent.	Sulphur, per cent.	Weight, per cent.	Ash, per cent.	Sulphur, per cent.
1·230	—	59·6	1·5	1·18	59·6	1·5	1·18
1·235	1·230	22·6	1·5	1·30	82·2	1·5	1·21
—	1·235	17·8	3·2	1·45	100·0	1·8	1·25

The weights of those portions, separated by liquids of various specific gravities, with their analyses, are shown under the heading "Direct." The weights and analyses of those portions obtained in the above direct manner, are successively combined in that part of the table headed "Cumulative."

A better separation than the above is not possible by any physical process. It is concluded therefore that the Assam coal cannot be cleaned. Mixed with Jharia coal the Assam coal gives a satisfactory coke, but the difficulties of mining and the great distance from the iron ore deposits are factors which have to be noted when the Assam coals are being considered as possible reserves of coking coal.

A specimen sample, Ref. No. 313, from another colliery, is even more homogeneous and has the following analysis :—

Ash . .	1·2 per cent.
Moisture . .	1·2 ,,
Volatile Matter	44·3 .
Fixed Carbon	53·3 ,,
	100·0

Sulphur . . ·2 per cent.

IV. NON-COKING COALS OF THE CENTRAL PROVINCES, AND BIHAR AND ORISSA.

Pench valley.

These coals are all of the sub-bituminous, non-coking type. A typical analysis is as follows :—

Ash . .	19 per cent.
Moisture .	6 ,,
Volatile Matter	29 ,,
Fixed Carbon	46 ,,

The coals contain a very small proportion of vitrain and are profusely banded with fusain. Vitrain picked out by hand has the following analysis :—

Ref. No. 359V.

Ash	0·8 per cent.
Moisture	10·9 ,,
Volatile Matter	34·5 ,,
Fixed Carbon	53·8 ,,

In the test for volatile matter the vitrain gives a weakly *fritted*, non-swollen residue. The other constituents of the coal are entirely non-coking. Hence the coal is incapable of being cleaned to yield coking products. The constitution of the coals is shown by the following results of heavy liquid separation :

Ref. No. 359. Face sample. Ash 20·8 per cent. B. Th. U. 10,500.

Specific Gravity of liquid on which it floats.	Specific Gravity of liquid in which it sinks.	DIRECT.			CUMULATIVE		
		Weight, per cent.	Ash, per cent.	B. Th. U.	Weight, per cent.	Ash, per cent.	B. Th. U.
1·50	—	65·0	12·6	11,700	65·0	12·6	11,700
1·57	1·50	16·4	28·4	9,600	81·4	15·8	11,200
—	1·57	18·6	42·9	7,550	100·0	20·8	10,500

The poorest of the constituents have fairly high calorific values. For this reason cleaning for general purposes is not likely to be profitable. Further, the surface properties of the constituents are such that an unusually large proportion of reagents is required to secure flotation of the better constituents.

Sasti ; Ghugus ; Tulsi, Bisrampur

These coals are all of the sub-bituminous, non-coking type and are considered to be not profitably cleanable.

Talchir.

The seams being worked are of excellent quality. The coal is sub-bituminous and is incapable of being cleaned to yield coking products.

Bhudyar Khad, Daltonganj.

Ref. No. 405.

Ash	19·5	per cent
Moisture	6·6	,,
Volatile Matter	30·9	,,
Fixed Carbon	43·0	,,

This is a sub-bituminous coal and is entirely non-coking.

It is of interest to note that another sample, Ref. No. 406, from Debi Rai Khad, which is in the same district as Bhudyar Khad, has a remarkably different constitution and indicates that coal of a more highly bituminous nature may be found in this area ; the analysis of this sample is as follows :—

Ref. No. 406.

Ash	13·5	per cent.
Moisture	1·2	,,
Volatile Matter	21·5	,,
Fixed Carbon	63·8	,,

The coal contains a small proportion of vitrain which is strongly coking. It is not commercially cleanable for coking because the proportion of coking constituents is very small.

Karanpura.

This field was not sufficiently developed to allow of representative samples being taken. Examination of specimens from South Karanpura shows that the coal from this portion of the field is sub-bituminous and non-coking.

V. NON-COKING TERTIARY COALS OF THE PUNJAB AND NORTH-WEST FRONTIER PROVINCE.

Maidan Range Coalfield, Punjab.

A typical analysis of coal from this field is given below :—

Ash . . .	6	per cent.
Moisture . .	4	,,
Volatile Matter	43	,,
Fixed Carbon .	47	,,
	100	

Sulphur . . . . 4 per cent.

Results of heavy liquid separation are as follows :-

Ref. No. 645. Face Sample.

Specific Gravity of liquid on which it floats.	Specific Gravity of liquid in which it sinks.	DIRECT.			CUMULATIVE.		
		Weight, per cent.	Ash, per cent.	Sulphur, per cent.	Weight, per cent.	Ash, per cent.	Sulphur, per cent.
1·40	—	88·4	1·9	} 4·0	88·4	1·9	} 4·0
1·50	1·40	6·1	6·0		94·5	2·1	
—	1·50	5·5	34·0	15·0	100·0	4·0	4·6

These figures show that even the better constituents of the coal contain a fairly large proportion of sulphur. Hence no cleaning process can give a product containing appreciably less sulphur than does the run-of-mine coal. The coals are non-coking.

Eastern End of Salt Range, North-West Frontier Province.

Seven samples from this field have the following mean analysis :—

Ash	23·6	per cent
Moisture	5·0	,,
Volatile Matter	34·6	,,
Fixed Carbon	36·8	,,
	100·0	

Sulphur 4·6 per cent.

The coals are sub-bituminous and are entirely non-coking. Results of examination by means of heavy liquid separation of a typical sample are set out below :—

Ref. No. 647. Face sample.

Specific Gravity of liquid on which it floats.	Specific Gravity of liquid in which it sinks.	DIRECT. Weight, per cent.	Ash, per cent.	Sulphur, per cent.	CUMULATIVE. Weight, per cent.	Ash, per cent.	Sulphur, per cent.
1·50	—	69·2	7·6	1·8	69·2	7·6	1·8
1·57	1·50	4·2	25·7	2·8	73·4	8·6	1·9
—	1·57	26·6	58·7	11·8	100·0	21·9	4·5

This result shows that the constitution of the coal allows of a useful amount of cleaning being done. Flotation tests indicate that the coal may be cleanable, but that the consumption of reagents will be exceptionally large because of the nature of the surface properties of this type of sub-bituminous coal. For this reason cleaning may not be profitable and the necessary research has not been undertaken.

The present relative importance of the coals dealt with in this paper can be gauged from Tables 6 and 7 from the Records of the Geological Survey of India, Vol. LV, pp. 174-175, which give the outputs of Gondwana and Tertiary coal in India respectively.

COST OF TREATMENT.

The following estimates of costs have been prepared from data supplied from England suitably amended to suit Indian conditions. The operating charges include power at 0·5 anna per unit, labour, supervision, flotation reagents, renewals, amortization, and royalty to Messrs. Minerals Separation, Limited. The figures are for a large plant designed to treat run-of-mine coal giving a clean product dewatered for coking. For simplicity it has been assumed that the remainder, or tailings, will be worthless, and that all costs are charged to the output of clean product.

Cost of feed. (Rupees per ton.)	Weight per cent of Clean Product.						
	50	60	65	70	75	80	85
	Cost of Clean Product. (Rupees per ton.)						
3 . .	7·6	6·4	6·0	5·6	5·3	4·9	—
4 . .	9·6	8·1	7·5	7·1	6·6	6·2	5·9
5 . .	11·6	9·7	9·1	8·5	8·0	7·5	7·1
6 . .	—	11·4	10·6	9·9	9·3	8·8	8·3
7 . .	—	—	12·1	11·4	10·6	10·0	9·5
8 . .	—	—	—	12·8	12·0	11·3	10·7
9 . .	—	—	—	—	13·3	12·5	11·8

A comparison of the advantages to be gained by cleaning, and the costs of treatment, is now possible. The ash figures given in the results of flotation tests may be replaced by values in rupees per ton and the figures so obtained may be compared with the table of estimated costs given above. It will be seen that if a coal is cheap and/or capable of yielding a large percentage of clean product, treatment may be profitable. Certain of the Indian coals fulfil these conditions. It is hoped to publish further information on the whole question as work developes.

Sampling is of very great importance. Although not given in this paper all data relative to the sections of the seams have been noted.

All the recorded results of analyses are from tests done in the laboratory of the Geological Survey of India by Babu Dulal Chand De. Calorific values given on page 244 are calculated by Goutal's formula from the proximate analyses and are sufficiently accurate for the purpose. Typical analyses are from several samples and are intended to show the differences between the different types of coals.

I wish to express my thanks to Messrs. Minerals Separation, Limited, and to Messrs. Villiers, Limited, their agents in India, for permission to publish this paper; to the several Companies who have given valuable assistance in the field work connected with this investigation; and to Dr. Pascoe, Director of the Geological Survey of India, for his appreciation of the possible importance of this work and his very considerable help in making arrangements for the use of the laboratory in his charge.

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SUBMARINE MUD ERUPTIONS OFF THE ARAKAN COAST, BURMA. BY J. COGGIN BROWN, O.B.E., D.Sc., *Superintendent Geological Survey of India.* (With Plate 17.)

INTRODUCTION.

ON the charts of those parts of the eastern shores of the Bay of Bengal, known as the Arakan coast, the following caution to navigators appears :—

"Mud volcanoes, which occur in the sea, frequently raise islets which may remain above water for some time or quickly sink, leaving dangerous shoals in their places, and a constant and careful look-out is necessary when navigating this coast."

The mud volcanoes of Ramri and Cheduba Islands were first systematically investigated by F. R. Mallet[1] in 1878, and a comprehensive summary of his account has been given by R. D. Oldham in the second edition of the Manual of the Geology of India.

Underlying the shallow waters of the eastern shores of the Bay of Bengal and stretching north and south of the islands already mentioned, there are other localities from which gas, oil and mud are ejected from time to time, sometimes quietly and without any marked disturbance, but, occasionally, with explosive violence, recalling the spasmodic paroxysms of the Cheduba mud volcanoes which distinguish them from others found elsewhere in the oil-bearing regions of Burma.[2]

In the words of Dr. E. H. Pascoe [3],—

"It cannot be too emphatically denied that in Burma the so-called "mud volcanoes" have anything whatever to do with volcanic phenomena. They are entirely due to the escape of gas, the mud and rock fragments being purely accidental accompaniments, and constitute a perfectly normal part of the hydrocarbon occurrences in the 'oil-belts'. There is every gradation between a small insignificant oil or gas seepage and the conspicuous mounds or cones like those on the Arakan Coast, whose terrific outbursts afford some excuse for their having been mistakenly attributed to volcanic disturbance."

[1] F. R. Mallet: "The Mud Volcanoes of Ramri and Cheduba"; *Rec., Geol. Surv. Ind.*, XI, pp. 188-207, (1878).

[2] R. D. Oldham: "A Manual of the Geology of India," pp. 20-22 (1893).

[3] E. H. Pascoe: "The Oil Fields of Burma"; *Mem., Geol. Surv. Ind.*, XI, p. 211, (1912).

The eruptions of the submarine mud volcanoes give rise to the new islands which appear at intervals off the Arakan coast and add to the ordinary perils of these seas.

Apart from the desirability of recording the occurrences for the benefit of navigation, they are of great interest from other points of view, especially for the light they throw on the geology of this part of the Bay of Bengal. To quote Dr. Pascoe again,—

> "Their latitude and longitude, for instance, would fix points of probable anticlinal crests. The time of the year at which they occur and even the state of the tide probably have some bearing upon the underground conditions giving rise to the eruptions. Samples of the ejectamenta are of course useful, especially if they should happen to be fossiliferous, since they might be recognisable fragments of known types of rock."[1]

To these suggestions may be added others, such as the vexed question of the means by which the emitted hydrocarbons occasionally become ignited and give rise to fiery eruptions far out at sea, and the connection, if any, which exists between the times of eruption and seismic disturbances elsewhere, for although in their origin they are not associated, contrary to public opinion, with either volcanoes or earthquakes, it has been suggested that the convulsive outbursts are sympathetic responses to seismic disturbances, that an earth-wave may, in fact, act as a hair trigger and detonate the underlying unstable system in which the "mud volcano" is initiated.

In 1885, Mallet published a list of the eruptions which had taken place up to that date.[2] A later one happened on Cheduba Island on 3rd July, 1886.[3] From that time until October, 1893, there are no records of any other disturbances of the group. Accounts of later eruptions have appeared in the *Records* from time to time until 1912.[4]

[1] E. H. Pascoe. "The Oil Fields of Burma"; *Mem., Geol. Surv. Ind.*, XI, p. 188, (1912).

[2] F. R. Mallet, "On the alleged tendency of the Arakan Mud Volcanoes to burst into Eruptions most frequently during the Rains"; *Rec., Geol. Surv. Ind.*, XVIII, pp. 124-125, (1885).

[3] F. R. Mallet: "Notice of a Fiery Eruption from one of the Mud Volcanoes of Cheduba Island, Arakan;" *Rec., Geol. Surv. Ind.*, XIX p. 268, (1886).

[4] J. Coggin Brown: "Recent Accounts of the Mud Volcanoes of the Arakan Coast, Burma"; *Rec., Geol. Surv. Ind.*, XXXVII, pp. 264-279, (1908); "Supposed Eruption of a Mud Volcano in the Straits of Cheduba, Arakan Coast, Burma." *Rec., Geol. Surv. Ind.*, XLII, pp. 54-56, (1912); "Eruption of a submarine mud volcano off Sandoway, Arakan Coast, Burma." *Rec., Geol. Surv. Ind.*, XLII, p. 278, (1912); "Fiery Eruption of a Mud Volcano on Foul Island, Arakan Coast, Burma" *Rec., Geol. Surv. Ind.*, XLII, p. 279, (1912).

In addition to these an account of a submarine eruption off Ramri Island, which was actually witnessed from the deck of a passing steamer, has been given by Dr. Pascoe.[1]

From 2nd March, 1912, the date on which the mud volcano situated on the submerged reef to the south of Cheduba, known as the Hlaing-bank-kon or as the "Drunken Sailor Rocks," burst into activity, until 1st May, 1914, when an islet appeared above the level of the sea to the south of West Baronga Island, and from that time until the 14th November, 1923, conditions appear to have been quiescent, or, if any eruptions have taken place, they have failed to attract attention, which is unlikely. It now remains to bring these accounts up to date by relating the narratives of observers. They are prefaced by the one which has already been given in part by Dr. Pascoe, but which has not yet appeared in the Records, while the Memoir in which it is reproduced is now out of print.

Submarine Eruption of 30th September, 1908.

On the 8th October, 1909, the Marine Department of the Government of India in Simla issued the Miscellaneous Notification No. 1318-M., being a copy of a telegram from the Secretary to the Government of Burma, to the Secretary to the Government of India, Marine Department, No. 201-C., dated Maymyo, the 6th October, 1909. The notification is given below:—

"Following telegram received from Port Officer, Akyab. *Begins.* Commander, S. S. Katoria, reports witnessed a great volcanic upheaval approximate latitude nineteen dash twenty-one and one-fourth longitude ninety-three dash twenty-two. first upheaval five thirty-five P.M., second five fifty P.M. thirtieth stop each lasting two to three minutes. *Ends.*"

On the 23rd November, 1909, Commander A. R. W. Handcock of the British India Steam Navigation Co.'s R. M. S. Katoria kindly forwarded the following account of these occurrences to the Director, Geological Survey of India:—

"On the afternoon of the 30th September, 1909, whilst on a voyage from Rangoon to Kyaukpyu, I observed a remarkable volcanic upheaval in latitude 19° 21¼′ north and longitude 93° 22′, an account of which may, I think, prove interesting to your Survey Department. The circumstances are as follows:—On the afternoon in question I was steaming up the coast at about 11½ knots an hour on a N. by. E. course, weather fine with passing clouds, and a light S. W. wind, when at

[1] E. H. Pascoe: "The Oil Fields of Burma"; *Mem., Geol. Surv. Ind.*, XL, p. 197.

5-30 P.M. suddenly there was a disturbance right ahead and about 5 miles distant. The disturbance at first resembled the thick black smoke of a steamer on a far off horizon ; this was quickly followed by clouds of steam somewhat resembling a near view of a waterspout in the making ; and about 20 seconds later a great upheaval of water and huge black masses of mud which were so clearly defined at their edges that they resembled great rocks being thrown up in the air, and at first I believed it to be an entire rocky island being thrown up out of the bed of the ocean. This lasted about two minutes, when it rapidly subsided, leaving the water muddy and discoloured round the scene of the upheaval. The height to which the upheaval reached was about 200 feet above the sea, and the length from east to west about 1,500 feet. These measurements are very nearly correct, as there was a steamer nearer the upheaval than I was myself, and as I was able to precisely place the position of the volcanoes, I was therefore in a position to judge dimensions by comparison. At 5-50 P.M. a second upheaval took place also lasting about two minutes, which was similar to the first one and in the same place, though the length from east to west of this, the second eruption, was about 1,000 feet only. The depth of water at the spot is about 13 fathoms. After the upheavals the wind in the vicinity dropped to a calm, though after steaming some 8 miles out to sea, the light S. W. wind set in again.

The clearly defined edges of the black mud as distinct from and not mixed with the surrounding water can, I believe, be accounted for by the fact that petroleum exists in more or less quantities about this part of the Burma coast, and the mud was probably saturated with oil.

The force represented to force up such a large body of mud and water from some 80 feet below the surface of the sea to 200 feet above the surface of the sea must have been very great."

Submarine outbursts of this character and extent have seldom been actually witnessed at the moment before. A search through the old records from 1843 onwards reveals the fact that although flames and their reflections from banks of clouds have been seen, both from the mainland and from the sea, although mud islets of varying sizes, with and without active craters, have been observed, this is the first occasion in which the actual process of a violent eruption at sea has been watched from start to finish. There are several accounts of eye-witnesses of eruptions of the mud volcanoes on land of course.

In one particular, Commander Handcock's narrative recalls that of an earlier observer. In the early hours of 15th December, 1906, a very severe submarine eruption of a mud volcano took place in latitude 19° 0′ 6″ N., and longitude 93° 24′ 20″ E., 8¾ miles in a north-west by north direction from the north-westernmost point of Cheduba Island. Four and a half miles south-east by south from the site lies Beacon Island, and it so happened that Mr. S. Dawson, the Inspector of Light Houses to the Government of Burma, was on this island at the time. He observed the new land at about 7 A.M. in the morning and "about 9 A.M. noted black smoke in two jets like that of a steamer in the distance, and these gradually turned to white steam issuing in one enormous 'cumulus' the whole length of, and above, the island. Later, huge volumes of black mud and water "spouting up into the air to a height of what must have been hundreds of feet" were seen.[1] Commander Handcock's report mentions thick black smoke recalling a steamer on a distant horizon, followed by clouds of steam and then by the eruption of water and black mud. The only material differences in the two occurrences are that the preliminary eruptions, which gave birth to the island on 15th December, 1906, were not witnessed, whereas those of the one under discussion were not large enough to raise an islet above sea-level at all.

Submarine Eruption about 1st May, 1914, off West Baronga Island.

On May 4th, 1914, a notification was issued by the Marine Department in Rangoon, stating that an active mud volcano had appeared in latitude 19° 40′ N. and longitude 93° 02′ 15″ E. Its height on May 1st was about 30 feet and its length about 1 cable, and it showed two summits. Its position was off the long island of West Baronga, near Tiger Point and apparently on the track of vessels between Kyaukpyu and Akyab.

Copies of the notification appeared in the Indian newspapers of May 5th, followed by more detailed accounts on the 6th and 8th of May.

From these it appeared that the island was first sighted from the S. S. "Katoria," a vessel belonging to the British India Steam Navigation Company, Ltd., on May 1st. No active eruption was noticed, but merely an island in a locality where there should have been clear water. In an interview with an "Englishman" representative, which appeared in that newspaper on May 6th, the Commander of the S. S. "Katoria" is reported to have made the following statement :—

"From all appearances it is an island, about a mile in extent and from 25 to 30 feet high. What confirms my conviction that it is an island is its proximity to the island of Baronga, and I should not be at all surprised if it is found to be a part of

[1] J. Coggin Brown : "Recent Accounts of the Mud Volcanoes of the Arakan Coast Burma." *Rec., Geol. Surv. Ind.*, XXXVII, pp 269-272, (1908).

this island. Another thing that strengthens my belief is the earthquake report issued from Simla last week, for that report stated that the shock came from about a thousand miles distance, and Baronga Island is just about that distance from Simla. Since no other report that would account for the shock has been made it is more than probable that this eruption was the quake recorded on the Simla seismograph."

Later accounts stated that the new mud island, situated about 8 miles south of Baronga Point, was the first to appear in the region for several years, although a number of years previously they were of common occurrence. The R. I. M. S. Mayo passed quite close to the island on the same day as the S. S. "Katoria," and a copy of the report from the Officer commanding the former vessel to the Port Officer, Akyab, is given below :—

"I have the honour to report that a mud volcanic island has appeared to the south of Baronga Point in latitude 19° 40′ N. longitude 93° 2′ 15″ E. Height about 30 feet, length about one cable, in two mounds.

A line of soundings was obtained off the island of 14 fathoms, L. W. O. S., from a position with the island bearing N. 60° E., true distance 2½ miles, to a position with island bearing N. 60° E., true distance 1 mile. Ship's course being N. 30° W. true. The water to the S.-E. of this volcanic island was discoloured for some distance, at least a mile or more. A heavy surf was breaking on the island at the time I was passing, and it was also blowing from the N.-W. (force about 7). I therefore did not lower a boat to make a close inspection.

Suggest that all shipping may be informed at the principal ports."

The island was slowly worn away by the action of the waves and tides and finally disappeared, leaving a dangerous shoal.

Submarine Eruption about November 14th, 1923, off West Baronga Island.

The Indian newspapers of November 16th, 1923, published the following information :—

"The Commander of the steamer 'Chakinda' reports that an island has been formed approximately 1,000 feet long and 20 to 30 feet high, in a position 8·4 miles south and 3 degrees east true from Baronga Point on the spot marked "Mud Volcano 1914."

A reference to the Commander of the S. S. "Chakinda" elicited the reply that he had no further information to add to this telegram.

At a later date the following report on the occurrence was received from Commander A. G. Maundrell, R.I.M., Port Officer, Akyab. It is a copy of one submitted to the Principal Port Officer of Burma.

"The island was examined on November 25th, 1923, and its position fixed as being 8·4 miles, 176 from Baronga Point. The island is composed of black mud, which, being in lumps, gives the idea of rocks, particularly so at the north and south points, where the washing away process has left a few pinnacles. The island is flat-topped, with perpendicular sides and slight ridge running north and south. It is now almost circular, of about 600 feet diameter and 20 feet in height. When fixing its position, the island was circled round at a distance of ¼ to ½ of a mile, and no sounding of less than 11 fathoms was obtained. The island was also circled round in a boat at a distance of not more than 200 yards. The island is washing away chiefly from the western side, on which side, at 200 yards distance, soundings of 4 fathoms to 7 fathoms were obtained. On the south side the island is steep to 9 fathoms, close along side on the east side 7 fathoms at 150 yards, and on the north side 7 fathoms at 200 yards. Inside of these distances the water shoals rapidly, and breakers are to be expected. Much discoloured water was passed through when circling the island, and this would appear to be chiefly due to the washing away process, it being noticed that on the flood this discolouration was mostly to the north-east and on the ebb to the westward. It is, I consider, likely that before long the island will disappear, leaving a dangerous shoal, as occurred in 1914.

Owing to the scend of the sea, it was impracticable to land."

The Port Officer adds that the island was first discovered by the Master of the S. S. "Chakinda" on November 14th, 1923, and that so far as he could ascertain, there were no eye-witnesses of the eruption.

The Geological Survey of India is also indebted to Commander Maundrell for a tracing of Admiralty Chart No. 1369 showing the exact position of the island and details of the soundings around it. A comparison of this with the chart itself shows that the new island coincides exactly in position with the one which was formed on May 1st, 1914, and there is no doubt that they were both due to eruptions of mud from the same vent in the floor of the sea.

The prediction that the island would disappear and leave a shoal was proved by the receipt of the following wireless message by the Principal Port Officer, Burma, on the 29th February, 1924, from the Master of the S. S. "Chantala."

"Island reported by Master, Chakdina, in position 8·4 miles S. S. E. true from Belonga Point has now disappeared and there is nothing showing above water. Breakers mark the position."

EXPLANATION OF PLATE 17.

Map showing position of mud volcano which erupted in May 1914 and November 1923. From Admiralty Chart No. 1369.

NOTES ON CRETACEOUS FOSSILS FROM AFGHANISTAN AND KHORASAN. BY THE LATE H. S. BION, B.SC., F.G.S., *Assistant Superintendent, Geological Survey of India.* WITH AN INTRODUCTION BY J. COGGIN BROWN, O.B.E., D.SC., *Superintendent, Geological Survey of India.*

INTRODUCTION.

(J. C. B.)

AMONGST the papers left by the late Mr. H. S. Bion at the time of his lamented death in June, 1915, were a number of notes on Cretaceous fossils from Afghanistan and neighbouring regions, which it was his intention to bring together into a paper for publication in the Records of the Geological Survey of India. Parts of the notes were typed out and finished, others were in manuscript, while in one or two cases merely the identification of the fossil itself had been made. Before proceeding to give a list of the forms recognised by Mr. Bion, together with such notes on them as he had prepared and his conclusions drawn from a study of the fauna, it is necessary to point out that the bulk of the collection was made by the late Mr. C. L. Griesbach during his deputation with the Afghan Baluch Boundary Commission. To these were added a few forms obtained by the late Sir Henry Hayden during his sojourn in Afghanistan, and one or two more collected by the late Dr. W. T. Blanford from the neighbourhood of Dera Ghazi Khan in the Punjab.

In 1887, Griesbach, as a result of the extensive traverses undertaken in earlier years, was able to demonstrate that rocks of Cretaceous age are widely spread over Afghanistan and Central Asia. They form a large part of Afghan Turkistan, and, to the west and north-west, extend in strips through the Herat province into North-Eastern Khorasan, where apparently all horizons from the Neocomian to the Upper Cretaceous *Exogyra* limestone are represented. Elsewhere, the lower portions of the system are missing. Griesbach found Cretaceous strata in great force between the Hindu Kush and Peshawar, in the south-western prolongations of the Central Afghan ranges, and in the Sulaiman Range. In Khorasan and Northern Persia, Cretaceous rocks form great ranges and play an important part in the structure of the mountain ranges which skirt the northern frontiers of Persia. In Central Asia proper, the Upper Cretaceous covers a large area and hides nearly all the older formations, which appear only in isolated patches where the overlying mantle has been denuded away. To Griesbach, already acquainted with the Central Himalayas and Kashmir, where Cretaceous rocks are comparatively rare, their vast expanses in the regions mentioned were at once arresting and remarkable. His terse descriptions of their prominent features are scattered through a series of papers published between the years 1885 and 1887 under the general title of "Afghan Field Notes." In the first of these, a short report on the geology of the Herat province,[1] there are brief preliminary notices of the Tir-band-i-Turkistan beds. In the second,[2] which deals with the Herat valley in more detail, and in addition with Eastern Khorasan, Griesbach divides the Cretaceous rocks of the latter region into a lower and upper group and traces their distribution generally. The third paper[3] describes reconnaissances carried out between the confines of Afghan-Turkistan and the district of Bamian in Afghanistan, which includes the areas north of the Tir-band-i-Turkistan and the Koh-i-Baba to the Oxus valley. Herein we find the Cretaceous system divided as follows :—

	Formations.	Localities.
Upper	White chalk with flints. *Inoceramus* sp., *Exogyra* sp., many bivalves.	Tir-band-i-Turkistan Range and anticlinals.
	Thick beds of white limestone with *Exogyra* sp.	Main mass of the Kara Koh and folds between Saighan and Tashkurghan.
Lower	Clays, shales, shell limestone, and beds with *Janira quinquecostata*.	Middle course of the Astar-ab and of the Almar Stream.

Detailed descriptions of the various sections are given, together with the following comment on the fauna :—"The commonest fossils found in this group are *Exogyra* sp. and *Janira quinquecostata* besides numerous others which have not been determined yet." Mr. Bion's investigations were concerned mainly with these then

[1] *Rec., Geol. Surv. Ind.*, Vol. XVIII, pp. 57—64 (1885).
[2] *Ibid.*, Vol. XIX, pp. 48—65 (1886).
[3] *Ibid.*, Vol. XIX, pp. 235—267 (1886).

undetermined remains. In the fourth paper,[1] Griesbach considers the geology of the country crossed by the Afghan Boundary Commission on its return to India across the Hindu Kush and through Kabul, while in the fifth [2] and last note, we find his general conclusions accompanying a geological sketch map of Afghanistan and North-Eastern Khorasan, as well as a table in which the Cretaceous rocks of Khorasan, Herat, Turkistan and South-Western Badakhshan are correlated with those displayed in the sections from Sibi to Kandahar and in the vicinity of Kabul.

A quarter of a century later, Sir Henry Hayden's memoir on the "Geology of Northern Afghanistan" was published.[3] Sir Henry in his introduction to this work, wrote :—" What little we know of Afghan geology is due chiefly to Mr. Griesbach's own work in that country between the years 1880 and 1888, the scientific results of which were published in the Records of the Geological Survey of India, Vols. XVIII, XIX, XX and XXV. Since that time nothing has been published on the subject, and the small amount of purely scientific work that I was able to do during a short tour undertaken primarily for the investigation of economic questions has tended to confirm on the whole, and to some extent to amplify, Mr. Griesbach's conclusions."

Describing the Cretaceous system, Sir Henry wrote :- " This comprises by far the most widely distributed group of rocks in Afghanistan to the north of the Koh-i-Baba and the Hindu Kush, From these ranges northwards to the plains of Afghan Turkistan, the whole area was formerly covered by a sheet of Upper Cretaceous limestone, which was deposited unconformably on all older formations." At the base of the series in the neighbourhood of Ishpushta, "there is a well-marked overlap, representing the great Cretaceous transgression which affected such a wide area in Central Asia and which is usually attributed to the Cenomanian period. Although fossils are fairly numerous in the beds above the basal limestone, I was unable to collect more than a very few, and these are all rather badly preserved. In Upper Saighan some shaly marls and arenaceous limestones yielded echinoids and ammonites, which my colleagues, Messrs. E. Vredenburg and G. H. Tipper, have been kind enough to examine for me." Mr. Vredenburg determined the

[1] *Rec., Geol. Surv. Ind.*, Vol. XX, pp. 17—26 (1887).
[2] *Ibid.*, Vol. XX pp. 93—103.
[3] *Mem., Geol. Surv. Ind.*, Vol. XXXIX, pp. 1—97 (1911).

echinoderms as *Micraster* sp. and *Cyphosoma sp.*, and pointed out that this was the first occurrence of the genus *Micraster* in **Asia**, and proved that the rocks from which it was derived could not be older than Middle Cretaceous, and probably not older than Cenomanian. Mr. Tipper referred the ammonites to the genus *Hoplites*. " A small fragment of *Scaphites* sp. and a brachiopod very closely allied to, if not identical with *Terebratula semiglobosa* D'Orb., also occur at the same horizon. The limestone overlying these beds is full of lamellibranchs, among which the genus *Exogyra* is very common and led Mr. Griesbach to call the rock, " Exogyra limestone." *Gryphæa vesicularis* Lam. occurs in this limestone at about 150 feet above the horizon of the ammonites and *Pecten* (*Neithea*) *quinquecostata* Sow. The limestones, therefore, are perhaps not older than Senonian, whilst the underlying marls may be as old as Cenomanian."

Such was the state of our knowledge of the Cretaceous faunas of these regions when Mr. Bion commenced his study of the fossils which Mr. Griesbach and Sir Henry Hayden had deposited in the collections of the Geological Survey of India in Calcutta.

Mr. Griesbach's specimens come from various localities in Khorasan and Afghan Turkistan, those collected by Sir Henry Hayden from the Saighan district of Afghanistan, while the few specimens which Dr. Blanford collected are from the Sulaiman Range in the Dera Ghazi Khan district of the Punjab.

List of the Forms identified by Mr. Bion.

Cyphosoma sp.

Micraster præcursor Rowe.

Serpula cf. *gordialis* Schlot.

Serpula filiformis Sow.

Terebratula sella Sow.

Terebratula obesa Sow.

Terebratula biplicata Sow.

Inoceramus balticus Bohm.

Gryphæa vesicularis Lam.

Exogyra decussata Coq.

Exogyra plicifera Duj.

Exogyra ostracina Lam.
Pecten (Neithea) quinquecostata Sow.
Spondylus calcaratus ? Forbes.
Lima obliquestriata Forbes.
Pholadomya cf. *gigantea* Sow.
Cardium sp.

NOTES ON THE FOSSILS.

(H. S. B.)

Cyphosoma sp.

There are two specimens representing this well-known Upper Cretaceous genus, but the preservation is too imperfect to allow of specific identification.

Locality.—K.11-328. Cretaceous marls near the base of limestone cliffs between Begal and Khárgin dara, Saighan, Afghanistan (lat. 35° 11′ : long. 67° 29′).

Micraster pracursor Rowe.

There are six specimens available for description, all more or less damaged. Five of these were collected by Sir Henry Hayden in the Cretaceous marls near the base of the limestone cliffs between Begal and Khárgin dara, Saighan (lat. 35° 11′ : long. 67° 29′). The cliffs alluded to are composed of the Upper Cretaceous *Exogyra* limestones, which are in great part of Campanian age. The exact locality from which the fossils came is marked on the photograph reproduced in Plate 3 of Hayden's memoir.

In the same memoir (p. 36) there is a short note by Mr. Vredenburg to whom the generic identification is due. The note is as follows :—" The four specimens of a spatangoid echinoderm are too crushed and too incomplete for specific determination. Nevertheless the generic characters are perfectly recognisable · the specimens belong to the genus *Micraster*, the extremely short ambulacral petals recalling forms from the Cretaceous of Europe. So far as I am aware, this is the first Cretaceous *Micraster* obtained in Asia. None, at least, is known from India or Persia. The rocks containing them cannot be older than Middle Cretaceous, probably not older than Cenomanian.[1]

Whilst looking through Mr. Griesbach's earlier collections one more specimen was found belonging to the genus *Micraster*. I have little doubt that it came from the same horizon as the Begal specimens, although it is in an extremely bad state of preservation. The locality given for this specimen is "below *Exogyra* limestone, Middle Cretaceous, Danda Shikan Pass, North of Saighan." The horizon is therefore probably exactly the same. When Mr. Vredenburg's preliminary identification was made the specimens had not been cleaned, and the ambulacra were filled with marl, hence a specific identification was impossible. Since I have cleaned the test, sufficient evidence is available to show that these Micrasters belong to the low zonal forms of the *M. præcursor* group of Rowe.[2]

Measurements.—The three best specimens only have been measured :—

Length	44	44	40 mm.
Breadth	44	41	35 ,,
Height	27	28	22 ..

These measurements serve to show the only anomalous features of the test, namely, that the breadth is in some fully equal to the length. This is a high zonal characteristic, associated as we shall see with many definite low zonal features. In this connection Rowe remarks—"It appears to be beyond doubt that in each zone there are broad varieties of the narrow forms."

It will be seen that the height is small, the test being depressed as in all low zonal forms. There is no appreciable development of rostrum or carina. The nature of the ambulacra and the interporiferous areas agrees very closely with that of forms from the *Holaster planus* zone of the English Chalk. The ambulacra are deep, trough-shaped, and practically smooth. To the naked eye they are certainly quite smooth, and even with the aid of a lens do not show any definite suturing of the inter-poriferous area. The single ambulacrum is a little more advanced as regards suturing and granulation than is the case with the paired ambulacra. It would appear as if the Afghan Micrasters approximate most nearly

[1] Mr. Vredenburg apparently saw only four of the Micrasters from Begal, but there are five in the collection.

[2] A. W. Rowe. "An analysis of the Genus *Micraster*." Q. J. G. S., Vol. LV, pp. 494--547, 1899.

to the passage forms between *M. leskei* and *M. præcursor*. The apical disc is excentric anteriorly. The amount of this excentricity is difficult to measure on crushed specimens, but averages about 4 mm. The mouth is very distant from the border, the measurement being made from the bottom of the notch to the anterior margin of the peristome. The distance so measured is about 9 mm.

The labrum is slight, triangular in shape, widest where it joins the plastron, and from there tapering to a point. The tip of the labrum is smooth, and the labral plate covered only by a few granules. The periplastronal area is only very slightly granulated.

Serpula cf. *gordialis* Schlot.

The only specimen referable to this species consists of round smooth tubes, one millimetre in diameter, irregularly entangled so as to form a nodular mass. There can be no doubt of the identity of this specimen with that figured by Stoliczka from Ariyalur, S. India.

Remarks.—*S. gordialis* is abundant in the uppermost Cretaceous beds of Germany, Northern Austria and France. It seems certain that Stoliczka's view that Sowerby's *S. plexus* from the English Chalk is identical with *S. gordialis*, is correct. The specimen here recorded also comes from the upper beds of the Cretaceous.

Locality.—H. 42/592. Upper Cretaceous limestone, Shadian, South of Balkh.

Serpula filiformis Sow.

Several blocks of limestone in the collection are covered with the long straggling bundles of tubes so characteristic of this species. I have satisfied myself by direct comparison, of the identity of these specimens with those figured by Stoliczka [1] and Kossmat [2] from the Ariyalur beds of Southern India.

Locality.—H. 42/403, H. 42/407. North slope of Zurmust Pass, N.E. of Herat.

H. 42/405. North slope of Band i-Zurmust, N.E. of Herat.

[1] Stoliczka. "Cretaceous Fauna of S. India." *Pal. Ind.*, Vol. 4, ser. VIII, p. 63, pl. XII, fig. 6.

[2] F. Kossmat. "The Cretaceous Deposits of Pondicherri." *Rec., Geol. Surv. Ind* Vol. XXX, pl. 10, fig. 7.

Terebratula sella Sow.

This well-known species is represented by several dozens of specimens from the "Firaiman beds" of Mr. Griesbach.

They were at first regarded as a variety of *T. gregaria* Suess, but subsequently identified by Sir Henry Hayden as *T. sella* Sow., an identification with which I am entirely in agreement.[1]

All the specimens correspond very closely with the true *T. sella* figured by Davidson,[2] rather than with the two other varieties of the species admitted by that author. The specimen from the Isle of Wight which Davidson figured on his Plate VII, fig. 6, fairly represents the Afghan form, there being none with the strongly elevated front shown in fig. 4. The globose variety *T. sella* var. *upwarense* Walker is not represented in the collection.

Locality.—H. 42/279, H. 42/280. 5 miles N.W. of Firaiman, Khorasan.

Remarks.—In England and Western Europe *T. sella* is a typical fossil of the Aptian, and the Afghan examples come from the same horizon.

Terebratula obesa Sow.

There are two specimens referable to this species. One, (H. 42/590) from Shadian, South of Balkh; the other (K. 11/328) from Cretaceous marls near the base of limestone cliffs between Begal and Khárgin dara, Saighan, (lat. 35° 11′ : long. 67° 29′).

The first is a very peculiar form, very wide at the shoulders and tapering to the anterior margin. I have not found any figured form to correspond and refer it with some hesitation to *T. obesa*. The second is a typical *T. obesa*.

Terebratula biplicata Sow.

There are several specimens of this species from the south-eastern slope of Koh-i-ah-i-Shora, south of Shadian, near Balkh, Afghanistan. They are all preserved as casts only (H. 42/513). Others are from Yakh Dara, west of Faughan, south-east of Maimana, Afghanistan (H. 42/574).

[1] Hayden, *op. cit.*, p. 34.
[2] Davidson, "British Fossil Brachiopoda," Vol. 1, plate 7, fig. 6, (1851-55).

Inoceramus balticus. Bohm. 1907.

There are several specimens in the collection belonging to this species, their localities being as follows :- H. 42/466, H. 42/467. Upper Cretaceous, south side of Kelat-i-Nadri, Khorasan. G. 373/2 Lower limestone shales between Mari and Dragal, Kaha Pass, West of Dera Ghazi Khan, (W. T. Blanford).

Mr. Griesbach's specimens are referred to under the name *I. cripsi* Mant. in his paper [1] "Afghan and Persian Field-Notes." It is clear that they come from the Upper Cretaceous beds, so that the present identification as *I. balticus* is in agreement with the stratigraphical position of the fossils. *I. balticus* is characteristic of the Senonian of Europe.

There has been considerable confusion in the use of the specific name *cripsi*, which has been applied wrongly to the Senonian form *I. balticus.* Woods has discussed this question.[2]

Both the specimens from Kelat-i-Nadri and those from the Kaha pass, W. of Dera Ghazi Khan, correspond with *I. balticus* and not with *I. cripsi.* The former is characterised by the much greater length in proportion to the height. The fine specimen of *I. cripsianmis* figured by Stoliczka [3] from the Ariyalur group of South India (which is of Senonian age), is undoubtedly identical with *I. balticus.* Bohm. It is a form intermediate in type between figs. 51 and 53 on pages 291 and 295 respectively of Woods' memoir. It will be seen from the footnote on page 296 that Woods was of the opinion that Stoliczka's specimen was really *I. balticus* and after examination of the type I am quite prepared to endorse this opinion.

Gryphœa vesicularis Lam.

An abundant fossil in the Ariyalur group of South India. It is characteristic of the Campanian beds of Europe and has been found in North America, Algiers, Syria and Asiatic Russia.

Localities.– K. 11/323. Top of the Cretaceous ; 4 miles south-east of Dasht-i-Safed, Afghanistan, (lat. 35° 20′: long. 67° 56′), (H. H. H).

K. 11/314. End of gorge of Kamard river, left bank, just above Andao, (lat. 35° 30′ : long. 67° 53′), (H. H. H.).

[1] *Rec., Geol. Surv. Ind.*, Vol. XIX, p. 63.

[2] H. Woods. "A Mo ograph of the Cretaceous Lamellibranchia of England," Vol. II Pt. VIII, p. 295, (1912).

[3] *Pal. Ind.*, Vol. III, p. 405, pl. XXVII, figs. 1—3, pl. XXVIII, fig. 2.

H. 42/550. Deh Surkh, Astar-ab valley, south of Sar-i-pul, Afghanistan, (C. L. G.).

H. 42/581. Yakh Dara, west of Faighan, south-east of Maimana, Afghanistan.

Exoygra decussata Coq.

This is the most abundant and characteristic fossil of the *Exogyra* limestone of Afghanistan. It occurs in the greatest abundance in certain beds, and as a general rule the larger inferior valve only is preserved. Owing to the strongly arched, gibbous nature of this valve it is impossible to clean out the matter so as to expose the internal characters, and judging by the published figures, very little is known about them.

A comparison of the specimens with those from the European Campanian forming Plate 7 of Coquand's Monograph shows how closely the Afghan forms resemble the European ones.[1]

Localities.—H. 42/527. Bajgah Gorge, between Mathar and Bajgah north of Saighan, Afghan Turkistan.

G. 373/2. Kaha Pass, between Mari and Dragal, Dera Ghazi Khan district, Sulaiman Range.

Remarks.—Among a few specimens brought back by Dr. Blanford from the Sulaiman Hills are some belonging to this species, and which have evidently come from the same set of beds, namely the *Exogyra* limestone of Afghanistan. In Europe *E. decussata* characterises the Campanian. The Afghan specimens and those from the Sulaiman Hills come in all probability, from a similar horizon.

Exogyra plicifera Duj.

The specimens referred to this species are in an excellent state of preservation, and the external and internal characters of both valves are to be seen.

They agree very closely with figures 14, 15, 16, Plate 36 of Coquand, though the Afghan form is more concave posteriorly than the European.

A few remarks are necessary concerning the superior valve. The figure given by Coquand (fig. 18) does not agree with my specimens in that the muscle scar is differently orientated in both. I am at a loss to explain the peculiar position of the muscle in Coquand's

[1] H. Coquand "Monographie du Genre Ostrea," Terrain Crétacé, Atlas, Pl. VII, figs. 1—17 (1 to 69).

figure which is reproduced from that given by Matheron for *E. midas.*

Beyond this feature and the slightly greater concavity in the outline of the valves, there is the closest resemblance between the Afghan forms and the European.

Locality.—H. 42/582. Shadian, South of Balkh, Afghanistan.

Remarks.—*E. plicifera* is stated by Coquand to occur in the Coniacian and Santonian, these divisions representing approximately the lower Senonian of more modern writers. The Afghan specimens appear to come from somewhere in the Upper Cretaceous *Exogyra* limestones.

Exogyra ostracina Lam.

Among the many members of the oyster family from the *Exogyra* limestone I have been able to find only one specimen, and that an isolated lower valve, which may safely be referred to *Exogyra ostracina.* This is rather surprising in view of the wide distribution of this species and its abundance in the South Indian deposits. Whether this rarity is due to the imperfection of the collection under description I am unable to say, but it may be remarked here that the species has not so far been recorded from the Baluchistan Cretaceous.

The length of the valve is 65 mm. and the height 48 mm. The outer or anterior side of the valve is nearly perpendicular, the inner side gently sloping and coated externally with foreign matter to which the animal in life was attached. In consequence of this the external characters of the shell are obscured. It may be observed however, that the beak was strongly and closely incurved, forming more than one complete volution and blending with the valve. The steep anterior side of the shell is rough and irregularly laminated.

The inner side is somewhat prolonged with shelly matter deposited on the object of attachment, but the original outline agreed with the specimens figured by Stoliczka from South India, the posterior margin being nearly straight.

The interior of the valve is well-preserved, and shows a finely crenulated pallial margin.

The muscle scar is a little peculiar, being nearly centrally situated, unusually large and strong, and of somewhat different shape to the published figures of this species. *E. ostracina* is however admittedly an extremely variable species and this variation is most marked both in the shape and position of the muscle scars.

Pecten (Neithea) quinquecostata Sow.

Locality.—H. 52/547. Near Deh Surkh, Astar-ab valley, south of Sar-i-pul, Afghanistan.

Remarks.—This species ranges from the Lower Greensand to the Upper Chalk.

Spondylus calcaratus ? Forbes.

Locality.—K. 11/314. End of gorge of the Kamard River, left bank, just above Andao (lat. 35° 20′ : long. 67° 53′) Afghanistan, (H. H. H.).

H. 42/556. South-eastern slope of Koh-i-ab-i-shora, south of Shadian, near Balkh, Afghanistan.

Remarks.—This species occurs in the Trichinopoly group (Turonian) of South India. As there are no spines or extra prominent primary ribs on the only available specimens, their attribution to *S. calcarratus* is doubtful and it is possible that they may represent *S. truncatus* Gold., though the ribbing is a most variable character.

Lima obliquistriata Forbes.

Locality.—K. 11/314. End of the gorge of the Kamard River, left bank, just above Andao, (lat. 35° 20′ : long. 67° 53′).

Remarks.—This species has been found in the Ariyalur group of South India.

Pholadomya cf. *gigantea* Sow.

This species is represented by one specimen, a cast in which all the shell structure has unfortunately been destroyed.

Measurements.

	mm.
Length	115
Height	58

The dimensions agree very well with those given by Woods and bring out the most characteristic feature of this species, namely its greatly elongated form. The length appears to be always nearly twice the height. The number of ribs and the other characters of the shell, in so far as they are observable, are in agreement with the published descriptions of this species.

Locality.—K. 11/328. Base of limestone cliff, between Begal and Khárgin dara, Saighan.

Remarks.—In England *P. gigantea* occurs in beds of Aptian age; in western Europe it is found in the Valenginian Neocomian and Aptian; in German West Africa, from the base of the Neocomian to the top of the Aptian. This Afghan specimen came from the beds just below the *Micraster* horizon and would appear therefore to occur here at a somewhat higher horizon, possibly the Cenomanian.

Cardium sp.

This cast of a Cardium appears to be allied to *Cardium productum* Sow., but the specimen is far too badly preserved for specific determination. As far as observable the characters of this species are present. The ribs were numerous and with the lines of growth seem to have divided the shell surface into a serrated series of rectangles so typical of the *Cardiidæ*. Traces of tubercles or spines are still to be seen on the front of the valve.

Locality.—K. 11/314. End of gorge in Kamard River, left bank, just above Andao, (lat. 35° 20′: long. 67° 53′).

Conclusions.

Mr. Bion summarized his conclusions as follows :—

"The fauna is dominated by lamellibranchs, of which the Ostræidæ are by far the most abundant group.

The conditions of deposit must have been those of a comparatively shallow sea, the maximum depth of water being reached during the great Upper Cretaceous transgression. It would appear as if during Upper Cretaceous times, Afghanistan had formed the eastern extremity of the South European province. Such a generalisation may seem premature, based as it is on a very small collection of fossils, nevertheless the similarity to the European fauna is so marked that the inference is perhaps excusable.

Unquestionably the chief feature of interest lies in the strong European affinity of the fauna. Almost without exception the species met with can be matched in Europe, and in no direction is this similarity more strikingly shown than in the occurrence of the typical Upper Chalk genera *Cyphosoma* and *Micraster*.

In all, 13 species have been identified ranging, probably, from the Vectian [1] to the Campanian."

[1] Vectian is the term adopted by A. J. Jukes-Browne for the Lower Greensand (*Proc. Geol. Assoc.*, Vol. XII, p. 262, 1891-92).

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To face Plate 13.

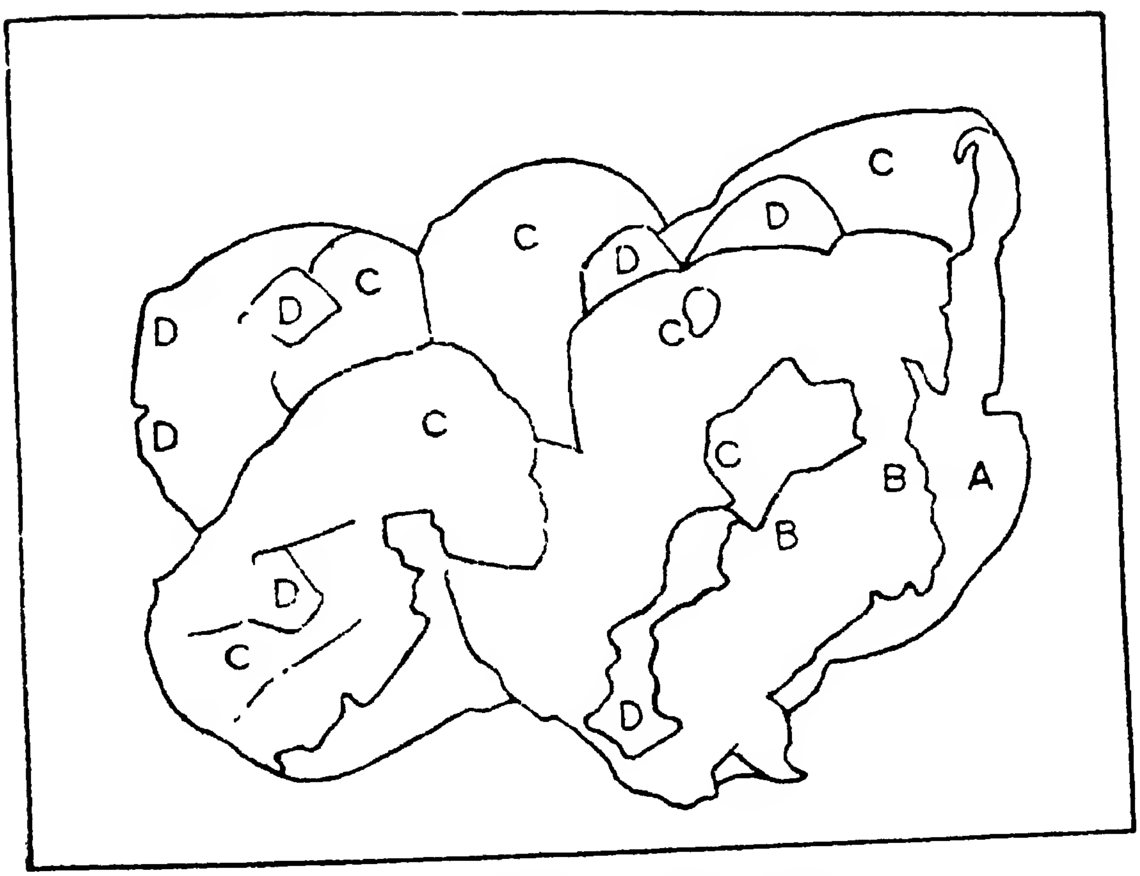
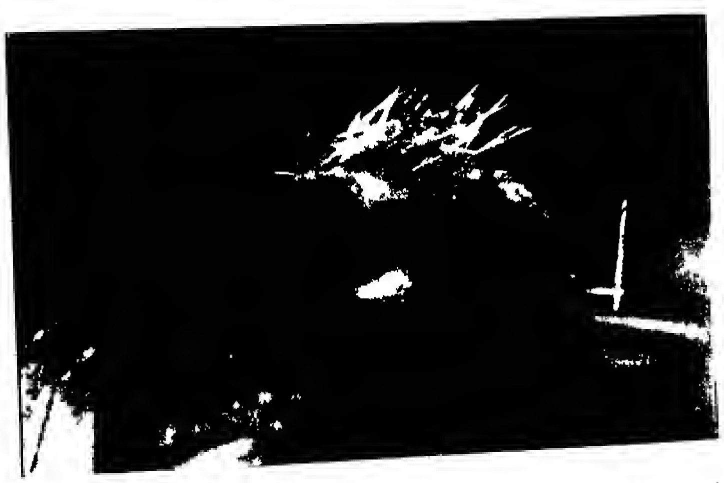


FIG. 2 OKENITE (*Natural size*).

A = trap ; B = laumontite ; C = okenite ; D = apophyllite.

FIG 1 GYROLITE ON CALCITE × 3

FIG 2 OKENITE (Natural Size)



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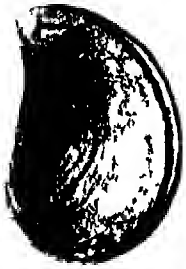
DAUNICHTHYS GREGORIANUS SP NOV × 3

Records, Vol. LVI, Pl. 15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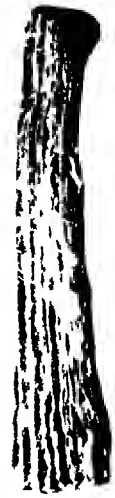
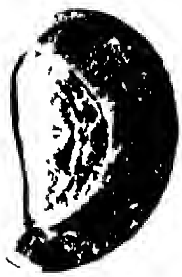

2b × 2


3 × 1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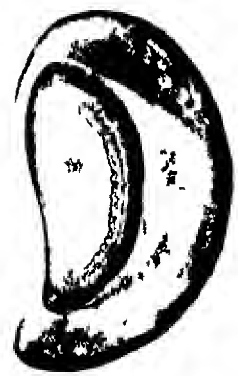
3a × 1


3b × 1


2 × 1


2a × 1

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FIGS 1, 1a, 2, 2a, 2b PACHYLABRA PRISCA, SP. NOV.
FIGS 3, 3a, 3b PACHYLABRA GLOBOSA

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Drawing Office, Photos.

TRIPLOPORELLA RANIKOTENSIS SP NOV